Integrated Terminal Weather System (ITWS) Operational Test (OT) Final Report - First Article Version Volume I

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16. Abstract

This Integrated Terminal Weather System (ITWS) Operational Test (OT) Final Report First Article Version Volume I documents the results of the Operational Test conducted by the William J. Hughes Technical Center Weather Processors and Sensors Group (ACB-630). This report is broken into two parts: Volume I documents the results of the First Article OT conducted at the Technical Center (Phase I), Kansas City (Phase II), and Houston (Phase III). Volume II documents the Production OT (Phase IV and V) conducted at the Technical Center and Atlanta, respectively. The OT Final Report format is in accordance with the Acquisition Management System (AMS), Test & Evaluation Process Guidelines, April 2002.

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EXECUTIVE SUMMARY

The Weather Processors and Sensors Group (ACB-630), of the Verification Service Division, William J. Hughes Technical Center (hereafter referred to as Technical Center), successfully conducted Operational Testing (OT) of the Integrated Terminal Weather System (ITWS) in accordance with the ITWS OT Test Plan. OT was conducted on First Article and Production ITWS systems. Volume I of the OT Final Report documents the First Article OT results; Volume II documents the Production OT results.

First Article OT was conducted in three phases. Phase I took place at the Technical Center. Phase II took place at Kansas City International Airport (MCI). Phase III took place at Houston George Bush Intercontinental (IAH) and Houston Hobby (HOU) Airports. Production OT took place at the Technical Center and Atlanta Hartsfield International Airport (ATL).

The most significant differences between the First Article and Production ITWS was the inclusion of Bandwidth Manager (BWM) and Transmission Control Protocol/Internet Protocol (TCP/IP) communications, and a hardware upgrade for the Product Generator (PG) and Situation Display (SD). In addition, Atlanta was the first site with the Low Level Windshear Alert System (LLWAS III) interface to the ITWS, and therefore this interface was tested in the field for the first time. Remote Maintenance Monitoring System (RMMS) and External Users Interfaces were not available, and were not tested during First Article or Production OT.

The objectives of First Article OT were to:

a. Examine ITWS operational performance characteristics (Phase I),

b. Ensure that ITWS could be integrated into the National Airspace System (NAS) without degradation of existing sensor performance (Phase I, II, III)

c. Verify operational and field interfaces (Phase II, III)

d. Examine ITWS operational performance characteristics at both simple and complex (multiple ASR-9 and TDWR inputs) sites (Phase II, III)

e. Determine that ITWS products and displays are useful to Air Traffic (AT) personnel

Air Traffic user evaluations were conducted as a part of Phase II and III OT.

The objectives of Production ITWS OT were to:

a. Compare the First Article System with the Production System,
b. Verify performance and maintenance improvements,
c. Verify the IP Network and Network Security, and
d. Evaluate Human Factors.

Airways Facilities (AF) user evaluations took place as a part of Phase V OT.

The Technical Center Production OT (Phase IV) focused on the integration of the sensors into the production ITWS, on product generation and display functionality, and testing the BWM interface. Comparisons were made between the First Article ITWS and the Production ITWS, in order to identify any possible degradation in performance or system usability. Production OT testing at ATL (Phase V) focused more on operational and sensor interface verification.

The following Critical Operational Issues (COI) were partially resolved:

COI-1:	Interoperability
COI-2:	Regional Effectiveness
COI-4:	System Resiliency
COI-5:	Enhanced traffic planning
COI-6:	ITWS Display
COI-7:	ITWS Configuration
COI-8:	Airport Capacity
COI-9:	ITWS Product Usability
COI-10:	ITWS Product Suitability
COI-12:	Controller Workload

The following COIs were not resolved or were deferred:

COI-3:	Remote maintenance monitoring
COI-11:	Performance Thresholds

Overall, the First Article OT was successful; a record of discrepancies was maintained in the ACB-630 Discrepancy Report (DR) database. A total of 165 DRs were written against the First Article ITWS. Two critical DRs remain open; one refers to an interpretation of the conditions under which the ITWS automatically changes to TWR backup mode (this may be closed, and addressed during training), and the other refers to certifying the Terminal Doppler Weather Radar (TDWR) during quarterly maintenance, while using the ITWS SD (a method to certify TDWR via ITWS SDs is being developed by AOS-250).

Raytheon corrected many of the DRs and others were made moot by virtue of hardware and software upgrades in the Production ITWS. Many of the 37 remaining open DRs deal with Interface Requirements Documents (IRD) discrepancies; the ITWS was designed and built according to specification, but in many cases, does not adhere to pre-existing IRD requirements.

The human factors data collected at MCI and IAH noted an overall positive reception to ITWS from users. Critical issues included the tornado product and the presence of unacceptable glare in the ITWS SD in the Air Traffic Control Tower (ATCT); both have been corrected. Some reductions in perceived workload were noted and both locations.

Given the success of First Article OT, the program preceded to Production procurement and testing at the Technical Center and Atlanta.

1. INTRODUCTION.

1.1 PURPOSE.

The purpose of this report is to document the results of the Operational Test (OT) of the Integrated Terminal Weather System (ITWS) system conducted by the Technical Center Weather Processors and Sensors Group (ACB-630). This report is broken into two parts; Volume I documents the results of the First Article OT conducted at the Technical Center (Phase I), Kansas City (Phase II), and Houston (Phase III). Volume II documents the Production OT (Phase IV and V) conducted at the Technical Center and Atlanta, respectively.

The Phase I OT was conducted in the ACB-630 Weather Laboratory at the Technical Center, using input sensors that reflect the intended end-state configuration of the Philadelphia ITWS.

The Phase II OT was conducted at Kansas City International Airport (MCI) in the Air Traffic Control Tower (ATCT), the Terminal Radar Approach Control (TRACON), and the Kansas City Air Route Traffic Control Center (ARTCC) (ZKC).

Phase III OT was conducted at Houston George Bush Intercontinental (IAH) and Houston Hobby (HOU) Airports, Houston TRACON (I90), and Houston ARTCC (ZHU).

Phase IV (Production OT) was conducted in the ACB-630 Weather Laboratory at the Technical Center.

Phase V (Production OT) was conducted in Atlanta, which included Hartsfield International Airport ATCT (ATL), TRACON, and Atlanta ARTCC (ZTL).

1.2 SCOPE.

This test report presents the results of the ITWS OT, based upon the data collected during First Article and Production OT testing at the Technical Center, MCI, IAH, and ATL, as described above. The OT Report is divided into 2 volumes; Volume I documents the results of First Article OT (Phases I, II, and II) while Volume II documents Production OT (Phases IV and V).

A list of the Discrepancy Reports (DRs) found during First Article testing is included as appendix A; Production DRs are included in Volume II. The questionnaire distributed to Air Traffic (AT) users (as a part of Phase II and III OT) is included as appendix B. The Workload Study distributed to AT users (as a part of Phase II and III OT) is included as appendix C, and the questionnaire distributed to Airways Facilities (AF) users (as a part of Phase V OT) is included in Volume II.

2. REFERENCE DOCUMENTS.

a. Operational Test (OT) Plan for the Integrated Terminal Weather System (ITWS), October 2000

b. ITWS Operational Test (OT) Procedures June 2001

c. ITWS Test and Evaluation Master Plan (TEMP), October 1995

d. Operational Requirements Document (ORD) for the Integrated Terminal Weather System (ITWS), February 1995

e. Acquisition Management System, Test & Evaluation Process Guidelines, November 1998

3. SYSTEM DESCRIPTION.

3.1 MISSION REVIEW.

The ITWS is a fully automated, integrated terminal weather information system that is intended to improve the safety, efficiency, and capacity of terminal area aviation operations. ITWS will provide Air Traffic personnel with tactical aviation weather products such as 6 level precipitation out to 200 nautical miles (nm), storm motion, storm extrapolated position, storm cell information, windshear, microburst, and gust front detection and prediction. Products and information will be displayed on ITWS Situation Displays (SD) installed in the ATCTs, TRACONs, and the Center Weather Service Unit (CWSU) and Traffic Management Unit (TMU) at associated ARTCCs.

To perform its mission, the ITWS acquires information from external systems that provide radar, weather sensor, and National Weather Service (NWS) data. Specified data sets from the NWS are acquired at the designated ITWS NWS Filter Unit (NFU) located at the FAA Technical Center and then communicated to the ITWS Product Generator (PG) sites via Government Furnished Equipment (GFE). The ITWS merges and processes the acquired data sets and provides weather products on displays for Air Traffic Control (ATC) personnel. The ITWS also provides products via designated output ports for access by aircraft data link processing and transmission systems, as well as for external users. For ITWS operations, interfacility communications are provided as GFE, either via the National Airspace Data Interchange Network II (NADIN-II), a national Packet Switching Network (PSN), or point-to-point terrestrial communications lines. The connection to NWS is provided as GFE via FAA Bulk Weather Telecommunications Gateway (FBWTG) service to the NFU. The NFU extracts portions of the NWS data for each ITWS. The Bandwidth Manager (BWM) was implemented prior to the Production OT. BWM replaces the NADIN connection as the communications link between the PGs and the ARTCC SDs.

3.2 TEST SYSTEM CONFIGURATION.

Test Configurations are depicted in figure 3.2-1 (Functional Diagram of the Technical Center First Article ITWS Architecture), figure 3.2-2 (Functional Diagram of the Technical Center First Article ITWS Test Tool Architecture), figure 3.2-3 (Functional Diagram of the MCI First Article ITWS Architecture), and figure 3.2-4 **(**Functional Diagram of the I90 First Article ITWS

Architecture). The ITWS Test Tool was developed by Raytheon to simulate sensor inputs to the PG. Table 3.2-1 defines the acronyms used in figures, these figures.

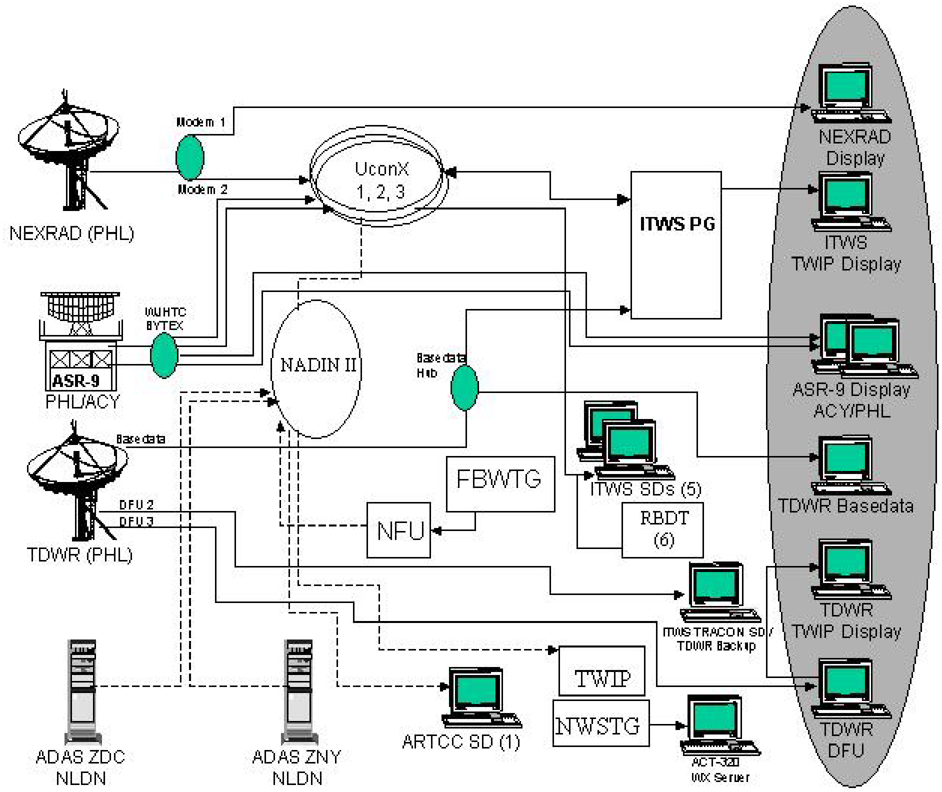

FIGURE 3.2-1. FUNCTIONAL DIAGRAM OF THE TECHNICAL CENTER FIRST ARTICLE ITWS ARCHITECTURE

For Phase II OT at Kansas City, the ITWS was connected to the Kansas City International Airport (MCI) TDWR and Airport Surveillance Radar – Model 9 (ASR-9), the Automated Weather Observing System (AWOS) Data Acquisition System (ADAS) from the Kansas City ARTCC (ZKC), and the Pleasant Hill, Missouri Next Generation Weather Radar (NEXRAD) (KEAX), representing the true operational configuration. Figure 3.2-3 depicts the OT Configuration for the MCI First Article ITWS site.

For Phase III OT I at Houston, the I90 ITWS was connected to the IAH and HOU TDWRs, the IAH and HOU ASR-9s, the Houston NEXRAD (KHGX), and the ADAS from the Houston ARTCC (ZHU), representing the true operational configuration. Figure 3.2-4 depicts the OT Configuration for the I90 First Article ITWS site.

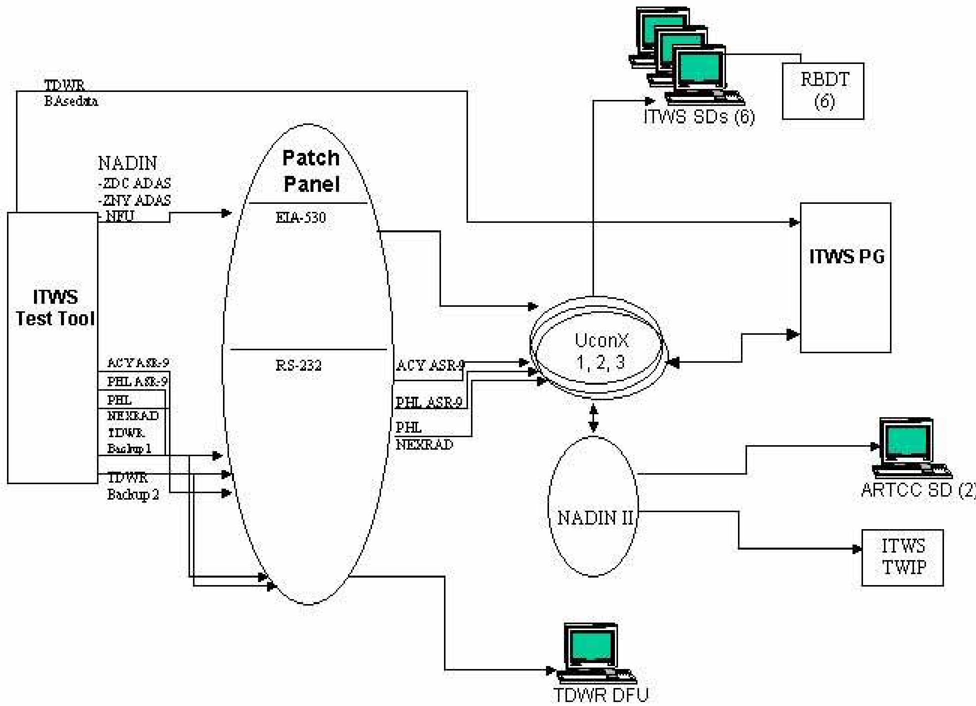

FIGURE 3.2-2. FUNCTIONAL DIAGRAM OF THE TECHNICAL CENTER FIRST ARTICLE ITWS TEST TOOL ARCHITECTURE

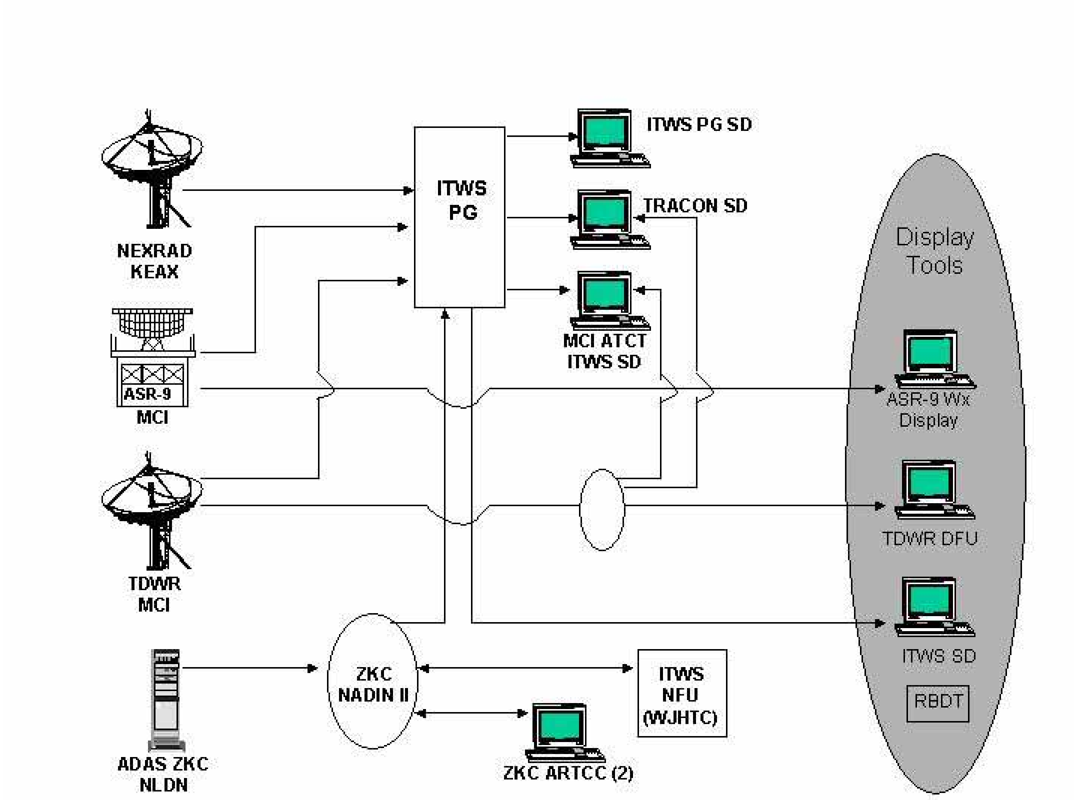

FIGURE 3.2-3. FUNCTIONAL DIAGRAM OF THE MCI FIRST ARTICLE ITWS ARCHITECTURE

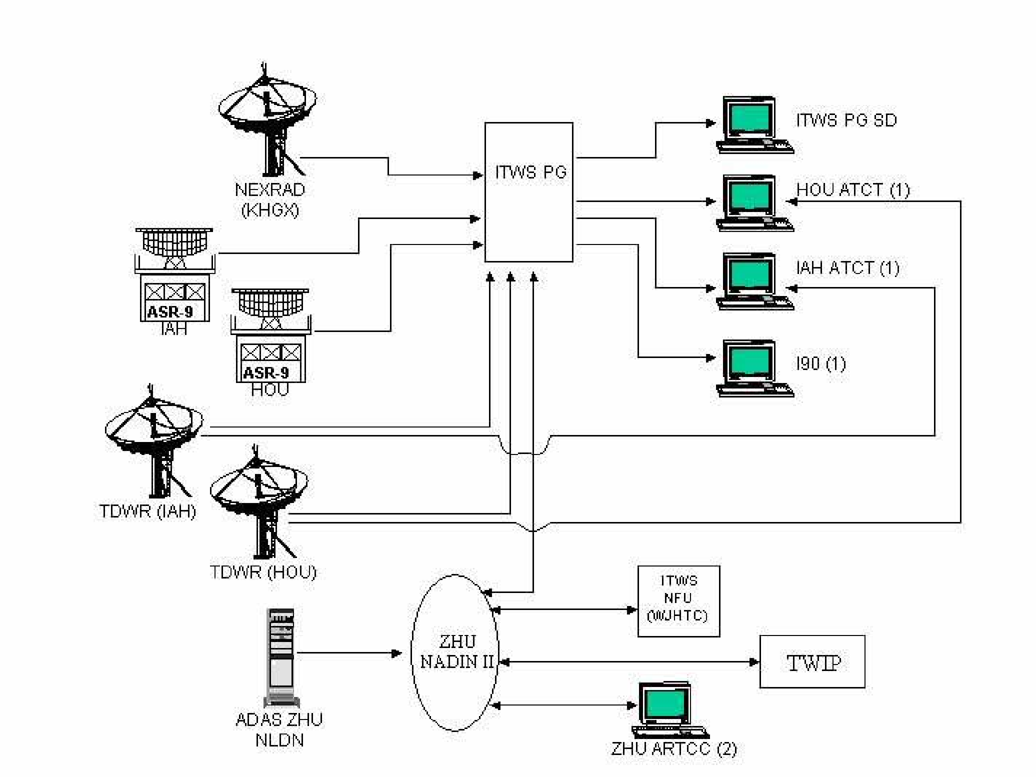

FIGURE 3.2-4. FUNCTIONAL DIAGRAM OF THE I90 FIRST ARTICLE ITWS ARCHITECTURE

TABLE 3.2-1. ACRONYMS FOR FUNCTIONAL DIAGRAMS

ACY	Atlantic City International Airport		NEXRAD	Next-Generation Weather Radar
ADAS	AWOS Data Acquisition System		NFU	NWS Filter Unit
ARTCC	Air Route Traffic Control Center		NLDN	National Lightning Detection Network
ASR-9	Airport Surveillance Radar- 9		NWSTG	NWS Telecommunications Gateway
ATCT	Air Traffic Control Tower		PG	Product Generator
DFU	Display Functional Unit		PHL	Philadelphia International Airport
FBWTG	FAA Bulk Weather Telecommunications Gateway		RBDT	Ribbon Display Terminal
HOU	Houston Hobby Airport		SD	Situation Display
IAH	Houston George Bush Intercontinental Airport		TDWR	Terminal Doppler Weather Radar
I90	Houston TRACON		TWIP	Terminal Weather Information for Pilots
KDIX	Ft. Dix, NJ NEXRAD		TRACON	Terminal Radar Approach Control Facility
KEAX	Pleasant Hill, MO NEXRAD		ZDC	Washington DC ARTCC
KHGX	Houston/Galveston, Texas WSR-88D/WFO		ZHU	Houston ARTCC
MCI	Kansas City International Airport		ZKC	Kansas City ARTCC
NADIN-II	National Airspace Data Interchange Network-II		ZNY	New York ARTCC

3.3 INTERFACES.

The following paragraphs discuss each of the individual ITWS interfaces; the discussion is divided between data source interfaces and data destination interfaces. The interfaces are established via the UCONX communication server, a direct connection, or the NADIN II PSN.

3.3.1 Data Source Interfaces.

The data source interfaces provide the input sensor data used by the ITWS PG to produce the ITWS products. The data source interfaces are via T1, voice grade telephone communications lines, and NADIN II.

3.3.1.1 Terminal Doppler Weather Radar (TDWR) Interface.

The TDWR is a C-Band radar optimized for the detection of precipitation and hazardous wind events in the immediate terminal area. The TDWR detects the wind events and, through correlation with information gained from scanning aloft, provides alarms and alerts of microbursts and gust fronts. TDWR products include six-level precipitation and windshear, microburst, and gust front detection and prediction.

The TDWR Radar Product Generator (RPG) provides base radar data and Low Level Windshear Alert System III (LLWAS) products (including Airport Winds) via T1 telephone lines to the ITWS PG. These data are then merged with data from other terminal weather sensors, as well as weather data from the NWS, to develop various ITWS products. LLWAS III was not available at the First Article OT sites, but was available in Atlanta for the Production OT.

When ITWS is in the TDWR Backup Mode, TDWR products are transmitted directly to the ITWS SDs for display. Only SDs at the ATCT and TRACON supervisor and traffic management positions will have access to TDWR data.

Table 3.3.1.1-1 summarizes the TDWRs utilized during OT.

TABLE 3.3.1.1-1. TDWRS UTILIZED DURING OT

PHASE	**LOCATION**	**TDWR**
Phase I	Atlantic City, NJ	PHL
Phase II	Kansas City, MO	MCI
Phase III	Houston, TX	IAH, HOU
Phase IV	Atlantic City, NJ	PHL
Phase V	Atlanta, GA	ATL

3.3.1.2 Airport Surveillance Radar – Model 9 (ASR-9).

The ASR-9 is a short-range radar that detects and tracks aircraft targets in the terminal environment within a 60 nm radius of the radar site. Six-level precipitation data from the ASR-9 is used as a source of reflectivity, storm motion, and storm extrapolated position (SEP) information in ITWS products. NEXRAD and TDWR are used in conjunction with the ASR-9 to identify areas of false weather radar returns, known as Anomalous Propagation (AP), thereby improving the accuracy of weather cell detection. Up to nine (9) ASR-9s are supportable by a given ITWS PG.

Table 3.3.1.2-1 summarizes the ASR-9s utilized during OT.

TABLE 3.3.1.2-1. ASR-9S UTILIZED DURING OT

PHASE	LOCATION	ASR-9
Phase I	Atlantic City, NJ	PHL, ACY
Phase II	Kansas City, MO	MCI
Phase III	Houston, TX	IAH, HOU
Phase IV	Atlantic City, NJ	PHL, ACY
Phase V	Atlanta, GA	ATL

3.3.1.3 Low Level Windshear Alert System (LLWAS) III.

The LLWAS III interface provides LLWAS III wind data directly to the ITWS SD to be used as a backup to the ITWS and TDWR. It provides threshold and center field wind data from wind sensors located near the runways. LLWAS III was only available in Atlanta during Production OT.

3.3.1.4 Next Generation Weather Radar (NEXRAD)(WSR-88D).

The NEXRAD is a long-range radar, providing weather products within a 200 nm radius of the radar site. Six-level precipitation data from the NEXRAD is used as a source of reflectivity, storm motion, and storm extrapolated position (SEP) information in ITWS products. Up to four (4) NEXRADs are supportable by a given ITWS PG.

Table 3.3.1.4-1 lists the NEXRAD products that are acquired in support of the ITWS precipitation, storm motion, SEP, and storm cell information products. Table 3.3.1.4-2 summarizes the NEXRADs utilized during OT.

TABLE 3.3.1.4-1. NEXRAD PRODUCTS

NEXRAD Product Number	NEXRAD Product Name
41	Echo Tops
59	Hail Index
60	Mesocyclone
61	Tornado Vortex Signature
93	Digital Velocity Product
97	Composite Reflectivity – 124 nm
98	Composite Reflectivity – 248 nm

TABLE 3.3.1.4-2. NEXRADS UTILIZED DURING OT

PHASE	LOCATION	NEXRAD
Phase I	Atlantic City, NJ	KDIX
Phase II	Kansas City, MO	KEAX
Phase III	Houston, TX	KHGX
Phase IV	Atlantic City, NJ	KDIX
Phase V	Atlanta, GA	KFFC

3.3.1.5 Automated Weather Observing System (AWOS) Data Acquisition System (ADAS).

The interface to ADAS is used to acquire Automated Surface Observing System (ASOS) AWOS, and National Lightning Detection Network (NLDN) data, via NADIN II PSN, for use by ITWS algorithms. Collected data includes lightning data, acquired from NLDN, and surface observations from AWOS and ASOS sensors. Up to five (5) ADAS interfaces are supportable by a given ITWS PG.

Table 3.3.1.5-1 summarizes the ADAS utilized during OT.

TABLE 3.3.1.5-1. ADAS UTILIZED DURING OT

PHASE	LOCATION	ADAS
Phase I	Atlantic City, NJ	ZDC, ZNY
Phase II	Kansas City, MO	ZKC
Phase III	Houston, TX	ZHU
Phase IV	Atlantic City, NJ	ZDC, ZNY
Phase V	Atlanta, GA	ZTL

3.3.1.6 NWS Filter Unit (NFU).

The NFU ingests Rapid Update Cycle (RUC) Model Data and Meteorological Data Collection and Reporting System (MDCRS) data via an interface with FBWTG. The RUC and MDCRS data are then parsed into data sets specific to each ITWS PG, thereby eliminating the need for each PG to receive and process all of this data. The NFU distributes this data to appropriate ITWS PGs via NADIN II for the First Article ITWS and the BWM Internet Protocol (IP) network for Production ITWS.

The First Article NFU is located at the FAA Technical Center, and supports the Technical Center, MCI, and I90 First Article ITWS systems. The Production NFU is also located at the Technical Center, but will be relocated to the Washington, D.C area (e.g. Air Traffic Control System Command Center (ATCSCC) in Herndon, Virginia, Washington ARTCC (ZDC), or Potomac Combined TRACON (PCT)) upon installation of the PCT ITWS.

3.3.1.7 NAS Infrastructure Management System (NIMS) Interface.

This interface is used to communicate between ITWS System Control Software (SCS) and the Maintenance Processor Subsystem (MPS). It allows for remote command, control, and performance monitoring of the ITWS by the Remote Maintenance Monitoring System (RMMS). This interface was not available for testing during either First Article or Production OT.

3.3.2 Data Destination Interfaces.

The data destination interfaces provide raw and preprocessed data from ITWS to various users. The First Article destination interfaces were via direct connection or NADIN II PSN. The NADIN II PSN destinations are the Data Link User, External User 1 and External User 2. The Production destination interfaces are via the BWM IP network, which includes the external users, and the NADIN II PSN.

3.3.2.1 Data Link User (DLU).

The Data Link User (DLU) interface exports ITWS products to the Data Link User via the NADIN II PSN. ITWS disseminates Terminal Weather Information for Pilots (TWIP), which consists of a text message and a character graphics message, to the Data Link User/NADIN II PSN via Aeronautical Radio Incorporated (ARINC). This data is also provided to AOS-250 in Oklahoma City. TWIP messages provide a summary of the weather conditions around the airport. The text message consists of airport impacts, terminal weather, and expected airport weather. The character graphics message provides an American Standard Code for Information Interchange (ASCII) coded map of microburst and gust front activity in the terminal area. The text and character graphic messages also include areas of significant precipitation and a summary of the storm movement in the terminal area. Up to eight (8) DLUs are supportable by a given ITWS PG.

3.3.2.2 External Users.

The External User interface is designed to make real-time ITWS information available (via the External User port) to external users such as the ATCSCC, Automated Flight Service Stations (AFSS), meteorologists at the NWS, airport operations personnel (airport/port authorities), air carriers, Air Force, Navy, and Coast Guard personnel, police departments, and other federal agencies. Volpe National Transportation Center is developing a web-based ITWS display, using the output of the EXU-2 port.

3.3.3 Internal Interfaces.

There are several interfaces that are internal to the ITWS system and are not National Airspace System (NAS) interfaces. These interfaces are either direct connection (MDT and PG Maintenance Playback) or via NADIN PSN (ARTCC and the NFU).

3.3.3.1 ARTCC SD.

In order to ensure common situational awareness between the terminal and ARTCC users, ITWS products are transmitted to TMU and CWSU in the ARTCC. The SD simultaneously provides independent windows depicting each ITWS airport environment to TRACON and ARTCC SD users. ARTCC SDs may receive products from multiple ITWS PGs. Each ITWS PG has the capability to transmit ITWS products to a maximum of four ARTCC SDs.

3.3.3.2 Maintenance Data Terminal (MDT).

The MDT provides a system monitoring, control function, and display interface for the ITWS PG. The MDT is a portable personal computer furnished by the government. The interface to the ITWS PG is via the local area network (LAN).

3.3.3.3 PG Maintenance Playback Capability.

The PG Maintenance Playback capability allows the maintainer to play back PG data for a specified time period. Data may be played back from disk for the previous six hours, or from previously recorded data from tape. The PG must be in Maintenance-Standby Mode to utilize Playback capability.

4. TEST DESCRIPTION.

The major OT components were categorized as Integration tests, Suitability tests, and Effectiveness tests. OT categories and sub-categories are shown in figure 4-1. Integration testing verifies that the system interfaces with existing elements of the NAS and that the NAS can operate with the new subsystem. Suitability testing evaluates the degree to which ITWS satisfies its availability, reliability, maintainability, safety, human factors, supportability, documentation, and training requirements. Effectiveness testing evaluates the degree to which the system meets NAS and product specification requirements, and whether ITWS accomplishes its mission when used by air traffic controllers and maintenance technicians in the operational environment. Effectiveness testing includes stress and NAS loading, degraded operations, site adaptation data, security, and transition switchover.

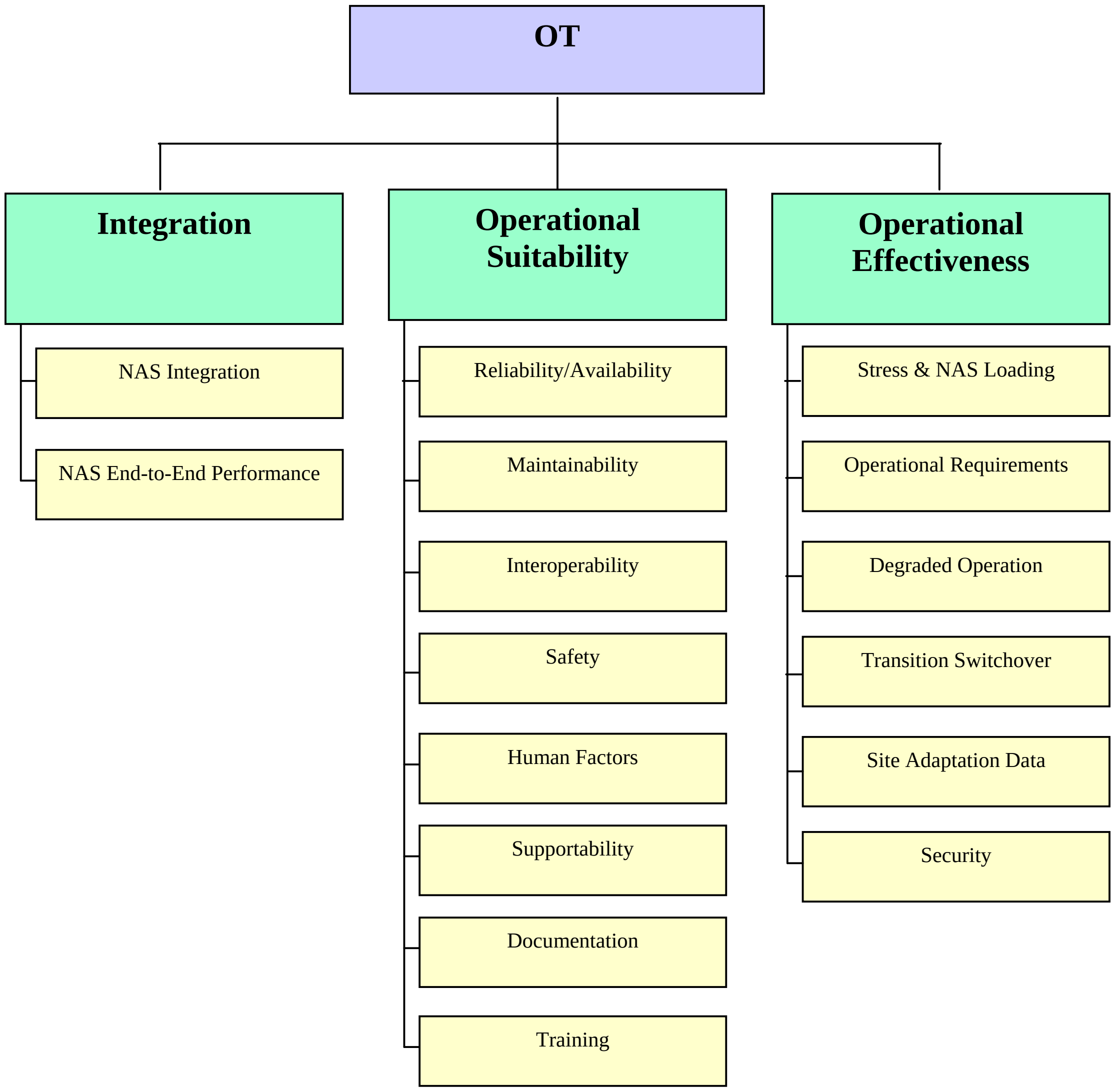

FIGURE 4-1. OT COMPONENT BREAKDOWN

During the functional testing of the ITWS NAS interfaces, the following test equipment was utilized:

RAD Protocol Analyzer, Model No. RC-100WFL	ACB-630 Weather Server
NEXRAD Test Pattern Generator*	PHL TDWR DFU
NEXRAD APUP Simulator*	PHL TDWR Base Data Display
NEXRAD Weather Display*	TDWR TWIP Display*
PHL ASR-9 Weather Display	ITWS TWIP Display*
ACY ASR-9 Weather Display	Frontline Test System break-out box
MCI ASR-9 Weather Display	IAH TDWR DFU
MCI TDWR DFU	

* - developed by ACB-630

4.1 PHASE I – TECHNICAL CENTER.

Phase I First Article OT took place at the Technical Center from February 6 – April 20, 2001. OT was conducted in the ACB-630 Weather Laboratory.

4.1.1 Test Objective.

The primary objective of Phase I OT at the Technical Center was to examine ITWS operational performance characteristics and to ensure that ITWS could be integrated into the NAS without degradation of existing sensor performance. The inter-facility links were verified by connecting ITWS to external systems and the NAS subsystems at the Technical Center. For the Technical Center OT, the Philadelphia International Airport (PHL) ITWS was emulated (thus the Technical Center site was physically configured like an operational site), using as many live interfaces as possible.

Phase I OT at the Technical Center focused to a great extent on the integration of the input sensors to the ITWS. Significant effort was put into ICD/IRD verification, product generation and display functionality.

The PHL TDWR, the PHL and Atlantic city International Airport (ACY) ASR-9, the Ft. Dix NEXRAD (KDIX), and the ADAS from New York (ZNY) and Washington (ZDC) were all connected to the Technical Center PG to generate PHL ITWS products, just as they will be when the PHL ITWS is installed. This enabled ACB-630 to conduct realistic testing, in a near-operational setting, using available meteorological and adaptation data. The ACY ASR-9 was added to the PHL configuration in order to evaluate the ASR-9 precipitation mosaic. The PHL and ACY ASR-9 interfaces were provided via the Technical Center BYTEX switch rather than the Remote Surveillance Communications Interface Processor (RSCIP), which would be the operational configuration.

4.1.1.1 Test Limitations.

Although the Technical Center ITWS interfaced with all the interfaces that will be a part of the eventual Philadelphia ITWS configuration, Phase I OT was conducted in a laboratory environment. Experienced AT personnel evaluated the ITWS products and SD in the Phase I laboratory environment, but since this was not a true operational environment, formal user evaluations were not a part of Phase I OT.

PHL, MCI and IAH do not have an LLWAS-III interface; therefore it was not tested as a part of the First Article OT. The majority of the ITWS sites do not have LLWAS-III, so while the First Article OT was representative from an interface perspective, it was not all-inclusive. LLWAS III testing was deferred until Phase V Production OT at Atlanta.

4.1.2 Test Description.

First Article OT entailed scripted (test procedures) and non-scripted test activities. ACB-630 personnel executed the scripted tests at the Technical Center, MCI, and I90. The non-scripted testing was performed by AT personnel from Orlando, New York, Houston and Philadelphia at the WHJTC; AT and AF personnel from MCI and I90 performed non-scripted testing at MCI and I90. The operational issues/problems discovered during OT were captured in ITWS DRs (appendix A).

As depicted in figure 4-1, the OT was broken into Integration, Operational Suitability, and Operational Effectiveness testing. Individual subtests associated with each of these areas are described below. Objectives, criteria, approach, and data analysis methods are addressed for each.

4.1.2.1 Integration.

The primary objective of OT Integration Testing was to examine ITWS operational performance characteristics and to ensure ITWS interfaces functioned properly and caused no degradation to existing NAS systems. A two-part test was used to address Integration: NAS Integration and NAS End-to-End Performance.

4.1.2.1.1 NAS Integration.

NAS Integration verified the interfacility link by individually connecting ITWS to external systems and the NAS subsystems at the Technical Center. NAS Integration verified the interface requirements in accordance with the appropriate NAS IRD/ICD document. This was accomplished in two phases: NAS Subsystem and NAS System.

4.1.2.1.1.1 NAS Subsystem.

4.1.2.1.1.1.1 Subtest 1 – RMS Interface Test.

4.1.2.1.1.1.1.1 Test Objectives.

The objective of this subtest was to functionally verify the RMS to ITWS-PG physical and functional interface requirements per NAS-MD-790 and NAS-MD-793A. This interface supports transmission of incoming and outgoing messages. These messages are: commands, information transfer, polling, link control, alert, alarm, return-to-normal, and certain state changes. Interoperability and error handling were verified for this interface.

4.1.2.1.1.1.1.2 Test Criteria.

The following characteristics of this interface were verified:

a. NAS-MD-790
b. NAS-MD-793A
c. Interface interoperability
d. Error handling/recovery

4.1.2.1.1.1.1.3 Test Approach.

Equipment control commands, mode changes, and status were exercised in order to validate the functionality of this interface in various states via NIMS and the local MDT. Alert, alarm, and return-to-normal notifications were tested using simulation that generates different types of alert, alarm, and return-to-normal conditions.

4.1.2.1.1.1.1.4 Data Analysis Methods.

Throughout each of the tests conducted as a part of the NAS Integration test, the data analysis method remained the same, and is described in this paragraph only. Protocol analyzer(s) were used to collect message frames transmitted between the ITWS-PG and the RMS. The data was then printed or transferred to PC for further data reduction using data reduction tools developed by ACB-630. The recorded data was inspected and verified offline. Available data was also collected on the ITWS PG and MDT.

4.1.2.1.1.1.2 Subtest 2 – ASR-9 Interface Test.

4.1.2.1.1.1.2.1 Test Objectives.

The objective of this subtest was to functionally verify the ASR-9 to ITWS-PG physical and functional interface requirements per NAS-IR-34032514. The interface provides for the transmission of weather data in the common digitizer (CD) format. Interoperability and error handling were verified for this interface.

4.1.2.1.1.1.2.2 Test Criteria.

The following characteristics of this interface are verified:

a. NAS-IR-34032514
b. Interface interoperability
c. Error handling/recovery

4.1.2.1.1.1.2.3 Test Approach.

The interface was exercised by using the ASR-9 as the data source for the PG. The ASR-9 transmits weather map data over its primary interface during normal operation and transmits data over a backup interface upon failure of the primary interface. This testing functionally verified which interface was active and that both interfaces conform to the IRD.

4.1.2.1.1.1.2.4 Data Analysis Methods.

Protocol analyzers were used to collect message frames transmitted between the ITWS PG and the ASR-9 primary and backup interfaces. The data was then printed or transferred to PC for further data reduction data reduction tools developed by ACB-630. The recorded data was inspected and verified offline.

4.1.2.1.1.1.3 Subtest 3 – ADAS Interface Test.

4.1.2.1.1.1.3.1 Test Objectives.

The objective of this subtest was to functionally verify the ADAS to ITWS-PG (via NADIN II) physical and functional interface requirements per NAS-IR-25082514. The ADAS data consists of One-Minute Observations (OMOs) and NLDN data. Interoperability and error handling were verified for this interface.

4.1.2.1.1.1.3.2 Test Criteria.

The following characteristics of this interface are verified:

a. NAS-IR-25082514
b. Interface interoperability
c. Error handling/recovery

4.1.2.1.1.1.3.3 Test Approach.

The interface was exercised by using the ADAS as the data source for the PG. This testing functionally verifies the interface was active and conforms to the IRD.

4.1.2.1.1.1.3.4 Data Analysis Methods.

Protocol analyzers were used to collect message frames transmitted between the ITWS PG and the ADAS. The data was then printed or transferred to PC for further data reduction data reduction tools developed by ACB-630. The recorded data was inspected and verified offline.

4.1.2.1.1.1.4 Subtest 4 – FBWTG Interface Test.

4.1.2.1.1.1.4.1 Test Objectives.

The objective of this subtest was to functionally verify the FBWTG to ITWS-NFU physical and functional interface requirements per NAS-IR-94142514. The FBWTG provides gridded forecast and airborne observation messages to the NFU. Interoperability and error handling were verified for this interface.

4.1.2.1.1.1.4.2 Test Criteria.

The following characteristics of this interface are verified:

a. NAS-IR-94142514
b. Interface interoperability
c. Error handling/recovery

4.1.2.1.1.1.4.3 Test Approach.

The interface was exercised by using the FBWTG as the data source for the NFU. This testing functionally verifies the interface was active and conforms to the IRD.

4.1.2.1.1.1.4.4 Data Analysis Methods.

Protocol analyzers were used to collect message frames transmitted between the ITWS NFU and the FBWTG. The data was then printed or transferred to PC for further data reduction data reduction tools developed by ACB-630. The recorded data was inspected and verified offline.

4.1.2.1.1.1.5 Subtest 5 – LLWAS III Interface Test.

4.1.2.1.1.1.5.1 Test Objectives.

The objective of this subtest was to functionally verify the LLWAS-III to ITWS-SD physical and functional interface requirements. The LLWAS-III provides wind shear alerts, microburst alerts, and runway threshold winds to the SD. Interoperability and error handling were verified for this interface.

4.1.2.1.1.1.5.2 Test Criteria.

The following characteristics of this interface are verified:

a. NAS-IC-31053102
b. Interface interoperability
c. Error handling/recovery

4.1.2.1.1.1.5.3 Test Approach.

The interface was exercised by using the LLWAS-III as the data source for the SD. This testing functionally verifies the interface was active and conforms to the ribbon display message format.

4.1.2.1.1.1.5.4 Data Analysis Methods.

Protocol analyzers were used to collect message frames transmitted between the ITWS SD and the LLWAS III. The data was then printed or transferred to PC for further data reduction data reduction tools developed by ACB-630. The recorded data was inspected and verified offline.

4.1.2.1.1.1.6 Subtest 6 – NEXRAD Interface Test.

4.1.2.1.1.1.6.1 Test Objectives.

The objective of this subtest was to functionally verify the NEXRAD to ITWS-PG physical and functional interface requirements. The NEXRAD provides control and status messages in addition to the weather products to the PG. Interoperability and error handling were verified for this interface.

4.1.2.1.1.1.6.2 Test Criteria.

The following characteristics of this interface are verified:

a. NEXRAD/RPG to Associated Principle User Processor ICD (2620001A)
b. Interface interoperability
c. Error handling/recovery

4.1.2.1.1.1.6.3 Test Approach.

The interface was exercised by using the NEXRAD as the data source for the PG. This testing functionally verifies the interface was active and conforms to the NWS message format.

4.1.2.1.1.1.6.4 Data Analysis Methods.

Protocol analyzers were used to collect message frames transmitted between the ITWS PG and the NEXRAD. The data was then printed or transferred to PC for further data reduction data reduction tools developed by ACB-630. The recorded data was inspected and verified offline.

4.1.2.1.1.1.7 Subtest 7 – TDWR Interface Test.

4.1.2.1.1.1.7.1 Test Objectives.

The objective of this subtest was to functionally verify the TDWR to ITWS-PG and ITWS-SD physical and functional interface requirements per NAS-IR-31052514 Part 1 and Part 2 respectively. The TDWR to PG interface provides TDWR base data. The TDWR to SD interface provides TDWR products. Interoperability and error handling were verified for these interfaces.

4.1.2.1.1.1.7.2 Test Criteria.

The following characteristics of this interface are verified:

a. NAS-IR-31052514, Part 1
b. NAS-IR-31052514, Part 2
c. Interface interoperability
d. Error handling/recovery

4.1.2.1.1.1.7.3 Test Approach.

The interface was exercised by using the TDWR as the data source for the PG and SD. This testing functionally verifies the interfaces are active and conform to the IRD.

4.1.2.1.1.1.7.4 Data Analysis Methods.

Protocol analyzers were used to collect message frames transmitted between the ITWS PG and the TDWR. Protocol analyzers were also used to collect message frames transmitted between the ITWS SD and the TDWR. The data was then printed or transferred to PC for further data reduction data reduction tools developed by ACB-630. The recorded data was inspected and verified offline.

4.1.2.1.1.1.8 Subtest 8 – Data Link User Interface Test.

4.1.2.1.1.1.8.1 Test Objectives.

The objective of this subtest was to functionally verify the Data Link User to ITWS-PG physical and functional interface requirements. The ITWS-PG provides Terminal Weather Text Messages to the DLU in accordance with the TWIP Enhancement to the TDWR. The interface transfers two types of weather data products. The first product type was ARINC Data Network Services (ADNS) formatted TWIP messages and the second type was Aeronautical Telecommunications Network (ATN) formatted TWIP messages. Interoperability and error handling were verified for these interfaces.

4.1.2.1.1.1.8.2 Test Criteria.

The following characteristics of this interface are verified:

a. ADNS message format
b. ATN message format
c. Interface interoperability
d. Error handling/recovery

4.1.2.1.1.1.8.3 Test Approach.

The interface was exercised by using the NADIN-II PSN as the data sink for the ITWS-PG. This testing functionally verifies the interfaces are active and conform to the ADNS and ATN message formats.

4.1.2.1.1.1.8.4 Data Analysis Methods.

Protocol analyzers were used to collect message frames transmitted between the ITWS PG and the NADIN-II PSN. Protocol analyzers were also used to collect message frames transmitted between the ITWS PG and the DLU port. The data was then printed or transferred to PC for further data reduction data reduction tools developed by ACB-630. The recorded data was inspected and verified offline.

4.1.2.1.1.1.9 Subtest 9 – External Users Interface Test.

4.1.2.1.1.1.9.1 Test Objectives.

The objective of this subtest was to functionally verify the External Users to ITWS-PG physical and functional interface requirements. The two External Users Ports, designated as External Users Type 1 and The External Users Port Type 2, receive all ITWS-PG products and all ITWS-PG display products, respectively. Interoperability and error handling were verified for these interfaces.

4.1.2.1.1.1.9.2 Test Criteria.

The following characteristics of this interface are verified:

a. External Users Type 1 message format
b. External Users Type 2 message format
c. Interface interoperability
d. Error handling/recovery

4.1.2.1.1.1.9.3 Test Approach.

The interfaces were exercised by using the NADIN-II PSN as the data sink for the ITWS-PG. This testing functionally verifies the interfaces are active and conform to the External Users Type 1 and Type 2 message formats.

4.1.2.1.1.1.9.4 Data Analysis Methods.

Protocol analyzers were used to collect message frames transmitted between the ITWS PG and the NADIN-II PSN. Protocol analyzers were also used to collect message frames transmitted between the ITWS PG and the External Users port. The data was then printed or transferred to PC for further data reduction data reduction tools developed by ACB-630. The recorded data was inspected and verified offline.

4.1.2.1.1.2 NAS System.

4.1.2.1.1.2.1 Test Objectives.

This test verified that the ITWS system was capable of interfacing with existing NAS subsystems and external systems simultaneously. The Technical Center ITWS was configured to represent the intended Philadelphia (PHL) ITWS physical configuration, with respect to sensor interfaces (New York and Washington D.C. ADASs, NADIN PSN node located at the Technical Center, the Ft. Dix NEXRAD, the FBWTG located at the ATCSCC in Herndon, Va., the PHL and ACY ASR-9s and the PHL TDWR. The PHL software adaptation set (which will be used when PHL is installed, and represents the PHL airspace, runways, overlays, etc.) was also installed on the Technical Center ITWS. The NADIN circuits provided a pathway to the remote SD(s), NFU and external users. In addition, archiving and archive playback were verified.

4.1.2.1.1.2.2 Test Criteria.

ITWS must be able to operate with all interfaces connected and simultaneously process weather data from the existing sensors without causing any degradation of the existing ATC NAS equipment. ITWS PGs must be able to receive and transmit products to the SDs. The ITWS must have the ability to archive and playback 6 hours of input data and 15 days of ITWS products.

4.1.2.1.1.2.3 Test Approach.

The ITWS NFU received NWS model and MDCRS data via the FBWTG in order to create the Terminal Winds product. The PG computer received live data from the sensors available at the Technical Center (ADAS, NEXRAD, TWDR, ASR-9); this live weather data was utilized to exercise the processing between NFU, PG and the SDs. Input data and products from these sources were periodically archived in order to exercise the archive and playback requirements, and to ensure that the ITWS processed and displayed the archived data and products.

4.1.2.1.1.2.4 Data Analysis Methods.

The system MDT was monitored to verify the performance of all interfaces that were operational during the test. The system log was analyzed to determine if any alerts/alarms are interface related.

4.1.2.1.2 NAS End-To-End Performance.

The area of NAS End-to-End Performance was addressed by a two-part test. The first part evaluated response times of the ITWS system and NAS subsystems and the second part evaluated system stability.

4.1.2.1.2.1 Response Times.

4.1.2.1.2.1.1 Test Objectives.

The Response Time Tests were conducted to assess the time required for product generation.

4.1.2.1.2.1.2 Test Criteria.

This test verified the product latency times identified in the ORD.

4.1.2.1.2.1.3 Test Approach.

A protocol analyzer was used to collect input data at the ITWS PG, SD, and NFU. The data were time stamped by the protocol analyzer(s) to calculate product latency.

4.1.2.1.2.1.4 Data Analysis Methods.

A protocol analyzer was used to collect message frames transmitted between the GFE communications equipment and the ITWS PG and ITWS NFU, and between the PG and SD. The data was then printed or transferred to PC for further data analysis, which included comparing the latency and response times for specification compliance.

4.1.2.1.2.2 System Stability.

4.1.2.1.2.2.1 Test Objectives.

This test provided assessment of the stability of the ITWS while operating continuously as part of the NAS for a period of 72 hours. During the test, personnel performed operational, maintenance and support functions. The results of the System Stability Test were evaluated to determine the extent of deterioration, if any, due to data management, storage buildup problems, memory leak/fragmentation, or any other problems that may arise from continuous, long-term operation.

4.1.2.1.2.2.2 Test Criteria.

ITWS must be capable of operating over a 72-hour period without interruption of service while under normal operational conditions.

4.1.2.1.2.2.3 Test Approach.

The ITWS was operated continuously for a 72-hours period. During this period all system operating modes were exercised. A scenario based on Philadelphia adaptation was used. Hands-on ATC, System Maintenance and support function were exercised.

4.1.2.1.2.2.4 Data Analysis Methods.

The system log was printed periodically throughout the test and analyzed to verify that the ITWS has been fully operational for the full 72-hour period.

4.1.2.2 Operational Suitability.

ITWS operational suitability verification validated ITWS reliability, maintainability, availability, safety, human factors, supportability, documentation, and training to measure the degree that the ITWS satisfies its intended field use. Operational suitability issues and objectives for each test procedure were observed and evaluated. Test performer response and comments were recorded on an OT Test Evaluation Matrix (TEM) and developed into ITWS Program Trouble Reports (PTRs) as necessary.

4.1.2.2.1 Reliability/Availability.

4.1.2.2.1.1 Test Objectives.

OT was conducted to estimate and/or verify that the reliability and availability requirements were achievable in an operational environment. Reliability measures the Mean Time Between Failures (MTBF).

4.1.2.2.1.2 Test Criteria.

The following were the ITWS system requirements for reliability/availability:

a. A minimum system MTBF of 2704 hours
b. An inherent availability of at least .999815.

4.1.2.2.1.3 Test Approach.

During OT test conduct, the ITWS was run in a "hands-off" mode and it was repeatedly demonstrated that failures of interrelated NAS subsystems did not affect ITWS reliability. Data was collected at the FAA Technical Center while the system was exercised, as it would be at an operational site. Data was also collected at MCI and IAH while the controllers and technicians were using the system in the operational environment as part of the Human Factors evaluation.

ITWS system failures were recorded, evaluated, and classified as critical or non-critical. In the event of system failure, diagnostics were performed and results were recorded. In the event of critical failure, system run time and down time were also recorded in the test log in order to calculate availability. ACB-630 used the same success criteria defined by Raytheon in the ITWS Reliability Test Plan (CDRL A12049).

4.1.2.2.1.4 Data Analysis Methods.

In addition to analyzing the results of Raytheon's Reliability Demonstration, ACB-630 calculated reliability by dividing the number of critical failures by total system run time. System event logs were monitored for failures. Availability was calculated by subtracting system down time due to critical failures from total system run time and then dividing by total system run time.

4.1.2.2.2 Maintainability.

4.1.2.2.2.1 Test Objectives.

OT was conducted to verify that the Maintainability requirements are achievable in an operational environment. Maintainability measures the Mean-Time-To-Repair (MTTR).

4.1.2.2.2.2 Test Criteria.

The following were verified in the operational environment: MTTR for the ITWS shall not exceed 0.5 hours.

4.1.2.2.2.3 Test Approach.

Maintainability was verified by injecting non-destructive faults into ITWS. A total of 30 faults were identified by ACB-630 with a subset of these faults being utilized at each site. The time for a trained FAA technician to isolate and correct the fault was recorded. All trained FAA technicians at each site had the opportunity to participate.

4.1.2.2.2.4 Data Analysis Methods.

The start and stop times of each maintenance action were recorded. The start time was recorded when the technician views the maintenance alarm. The end time was recorded when the system was returned to operation. The MTTR were calculated for each key site and for both sites combined. The median and standard deviation statistics were also calculated.

4.1.2.2.3 Interoperability.

4.1.2.2.3.1 Test Objectives.

This test verified ITWS capability to operate with existing NAS subsystems in an operational environment.

4.1.2.2.3.2 Test Criteria.

Please refer to paragraph 4.1.2.1.1.2.

4.1.2.2.3.3 Test Approach.

Please refer to paragraph 4.1.2.1.1.2.

4.1.2.2.3.4 Data Analysis Methods.

Please refer to paragraph 4.1.2.1.1.2.

4.1.2.2.4 Safety.

Safety was evaluated to determine that ITWS met physical safety requirements. Safety considerations focused on system equipment being designed and constructed so that it does not cause personal injury during installation, operation, and maintenance. Safety requirements include personnel safety, hazardous materials, physical safety, electrical safety, cabling/connections, electrical code adherence, and fire resistance.

4.1.2.2.4.1 Test Objectives.

Personnel Safety: Test that the system equipment is in compliance with equipment design, radio frequency/microwave, X-ray, laser radiation limits, and noise criteria.

Hazardous Materials: Test that the system components and materials are in compliance with toxic hazards, gases, fumes, explosive atmosphere, mercury, cadmium, and glass fiber criteria.

Physical Safety: Test that the system is in compliance with physical safety criteria.

Electrical Safety: Test that the system is in compliance with electrical safety criteria.

Cabling/Connections: Test that cabling and connections do not impede operations.

Electrical Code Adherence: Test that the cable installation is in compliance with installation criteria.

Fire Resistance: Test that the system is in compliance with fire resistance safety criteria.

4.1.2.2.4.2 Test Criteria.

Personnel Safety: The requirements stated in the System Level Specification (SLS) paragraphs 3.7.1.1 through 3.7.1.3 were tested for compliance with FAA-G-2100F sections 3.3.6.2, 3.3.7.1.1, and 3.3.7.1.2 and UL1950.

Hazardous Materials: The requirements stated in the SLS paragraph 3.7.2.1 were tested for compliance with MIL-STD-1472D, section 5.13.7.4 and requirements stated in SLS paragraphs 3.7.2.2 through 3.7.2.7 were tested to ensure that no gases and fumes were produced, and prohibited materials were not used.

Physical Safety: The requirements stated in the SLS paragraph 3.7.3 were tested for compliance with UL1950, section 4 and associated subsections.

Electrical Safety: The requirements stated in the SLS paragraph 3.7.4 were tested for compliance with UL1950, section 2.

Cabling/Connections: The requirements stated in the SLS paragraph 3.7.5 were tested to ensure that daily operations were not impeded by the cabling and connections.

Electrical Code Adherence: The requirements stated in the SLS paragraph 3.7.6 were tested for compliance with National Electrical Code, NFPA 70.

Fire Resistance: The requirements stated in the SLS 3.7.7 were tested for compliance with UL1950, section 4.1.2.

4.1.2.2.4.3 Test Approach.

ACB-630 personnel witnessed and verified ITWS compliance with established standards for Personnel Safety, Hazardous Materials, Physical Safety, Electrical Code Adherence, and Electrical Safety, during Site Acceptance Testing (SAT) and Raytheon. No changes occurred between SAT and OT, therefore a visual inspection of the ITWS equipment was conducted at the Technical Center.

Cabling/Connections: Requirements for cabling and connections were verified and the results were evaluated by the inspection method. While performing daily operations, cabling and connections installation impediments were noted and evaluated against the facility operators' performance.

4.1.2.2.4.4 Data Analysis Methods.

A safety checklist was used to collect the aforementioned safety data. This checklist was performed on each piece of ITWS equipment (e.g., SD, PG, NFU). The checklists were inspected and failures resulted in DRs.

4.1.2.2.5 Human Factors.

HF evaluations were conducted to assess the interaction of AT personnel with the ITWS system in the operational environment. Field personnel were requested to complete questionnaires and participate in interviews, which provided a method for collecting data, to quantify their interaction with the ITWS system.

4.1.2.2.5.1 Test Objectives.

The objective of the human factors portion of the OT was to evaluate the ITWS in an operational setting and assess its use by air traffic control personnel. Of particular interest were the computer-user interface, ITWS product utility, ease of use, and comprehension of the products. Workload impact; i.e. the degree to which the ITWS enhanced or degraded the capability of AT personnel to perform specific tasks (changing and choosing runways, planning air traffic flow, planning airspace use, rerouting aircraft, and avoiding adverse weather), was also assessed. Results of Human Factors testing were used in establishing the success of ITWS in meeting related Critical Operational Issues (COIs) and human factors-related ORD requirements.

4.1.2.2.5.2 Test Criteria.

A five point Liekert rating scale was used in the AT questionnaires; COI-12 requires a decrease in perceived workload as a result of using ITWS. Similarly, COI-9 and –10 require an overall positive response for the product utility, ease of use, and interpretability.

4.1.2.2.5.3 Test Approach.

Questionnaires were administered and were conducted in order to measure the users' impression of the ITWS SD and products. Questionnaires quantified the users' opinions of the utility, ease of use, and understandability of each ITWS product, as well as the SD in general.

Workload analyses quantified how users perceived the ITWS affected their ability to perform six specific AT related tasks, and the difficulty level in performing each of them, both prior to the availability of ITWS and after having used the ITWS.

HF evaluations were conducted in both Houston and Kansas City. Kansas City users had exposure to and use of the ITWS prior to the pre-ITWS Workload baseline data being collected, thus reducing the validity of that data.

The following list was used to evaluate applicable human factors performance with respect to the operation and maintenance of ITWS:

ITWS I/O Devices: System I/O display criteria adheres to the following:

a. ITWS SD/MDT - Graphics and text were clearly legible under all operational lighting conditions.
b. ITWS Workstation Keyboards - Keyboards are effective and easy to use. Characters are legible under various lighting conditions.
c. ITWS Mouse/Trackball - The mouse/trackball was accessible and easy to use.
d. ITWS Line Printers - Text was clearly legible and System Log message formats are easily understood. SD can produce hard copy of SD color images.
e. Menu Displays - Menus are well organized and are an aid to air traffic personnel and maintenance technicians.
f. Status Displays - All pertinent data was displayed logically and in an easy to use format.

Labor Intensive: The ITWS system can be used without requiring an inordinate effort, which may distract from the primary tasks.

Response Time: ITWS system response time was adequate to keep up with specialist actions.

Alarms/Alerts: Alarms/Alerts are adequate to attract attention but not unnecessarily disruptive. Status lights indicate proper system status, are readily and easily understood, and do not distract from position operation.

Error Detection: Input parameter limitations cannot be exceeded (e.g., incorrect values are detected and flagged, or rejected). Users determined the effectiveness of alarms/alerts.

Safety: The system does not present any safety hazards to the user, the facility, or other interfaced systems.

4.1.2.2.5.4 Data Analysis Methods.

The workload data (pre- and post-ITWS) were collected and analyzed to determine a) how much impact the use of ITWS had on perceived workload; b) if there are any tasks that were hindered by the use of ITWS; c) if there was indeed a reduction in perceived workload, how do the results from the OT sites (Kansas City and Houston) compare to results from similar analyses previously conducted for the ITWS prototype sites (Memphis, Orlando, Dallas-Fort Worth, and New York).

The questionnaire data were gathered and presented similarly. The data were separated both by position (Traffic Management Coordinators (TMC), Supervisors (SUP), etc) and by facility (tower, TRACON, ARTCC) to determine any discrepancies in the products or displays that were peculiar to a specific position or facility. Individual products were assessed for their respective ease of use and utility. The products were rated to determine if any products are deemed to hinder AT personnel job performance, and thus may be unacceptable for inclusion in the ITWS product suite.

The results from these analyses were compared to results from similar analyses conducted previously at the four ITWS prototype sites.

4.1.2.2.6 Supportability.

This evaluation verified the supportability of the ITWS system. Subtests included Logistics and Program Support Facility (PSF).

4.1.2.2.6.1 Subtest 1 – Logistics.

4.1.2.2.6.1.1 Test Objectives.

Logistics OT evaluated the supportability of ITWS in an operational environment. Test procedures and scripts were developed to stimulate typical operational use. This test evaluated ITWS training, documentation, human factors and logistics.

4.1.2.2.6.1.2 Test Criteria.

Logistics test procedures were performed and an overall assessment of the logistics support approach for ITWS was conducted. OT verified that the planned maintenance and logistics support are in place and provided adequate support for ITWS on the basis of logistics and maintenance expediency (response time), mean time to repair, availability and quantity of site and spare parts, and procedures are established to dispose of defective equipment.

4.1.2.2.6.1.3 Test Approach.

Logistics support were evaluated throughout the course of OT using applicable Operational Suitability issues selected from the following:

Expediency: Can spare parts, etc., can be obtained in a reasonable time?

Turn-Around: Does the system meet the MTTR requirement?

Compatibility: Are spares compatible with the system?

Source Validation: Are Government activities and contract supply vendors available to provide adequate spare parts replacement for ITWS as required?

Quantity: Are the sites stocked with sufficient site spares to prevent adverse impact on system operation?

Disposal: Are procedures in place to dispose of defective equipment?

4.1.2.2.6.1.4 Data Analysis Methods.

A logistics checklist was used to collect the aforementioned logistics data. This checklist was performed on each piece of ITWS equipment (e.g., SD, PG, NFU). The checklists were inspected and failures resulted in DRs.

4.1.2.2.6.2 SubtestT 2 – PSF.

4.1.2.2.6.2.1 Test Objectives.

The objective of the Operational Support Systems testing was to evaluate the capability of the various support units to support their assigned sites.

4.1.2.2.6.2.2 Test Criteria.

The ITWS system must be able to accept modified site parameters and rebuild to a new program reflecting the modified parameters. The application software must be designed for an industry standard operating system.

4.1.2.2.6.2.3 Test Approach.

The Raytheon Software Engineering Environment (SEE) Acceptance Test was used to verify this operational issue.

4.1.2.2.6.2.4 Data Analysis Methods.

The data collected during Raytheon's SEE Acceptance Test were analyzed by AOS-250 with support from ACB-630.

4.1.2.2.7 Documentation.

Documentation and technical drawings provided with ITWS were utilized and evaluated throughout the course of Operational Suitability testing. System manuals, software user manuals, technical instruction books, maintenance handbook, and other documentation were evaluated on the completeness, readability, accuracy, quantity, organization, and durability during the test.

4.1.2.2.7.1 Subtest 1 – Contractor Documentation.

4.1.2.2.7.1.1 Test Objectives.

The objective of the Contractor Documentation test was to ensure that the contractor documentation contains a complete set of installation, operation, and maintenance instructions for the ITWS.

4.1.2.2.7.1.2 Test Criteria.

This test determined whether the contractor documentation provides sufficient detail to enable a qualified technician to perform operator or maintenance functions, as appropriate on the ITWS. In addition, it determined if these instructions are presented with sufficient clarity and consistency to enable such functions to be exercised in a timely manner.

4.1.2.2.7.1.3 Test Approach.

Selected Test Team members attempted to exercise installation, operation and maintenance manuals, as listed below:

a. CDRL 12036 – ITWS System Software User's Manual (SUM)
b. CDRL 12037 – NFU SUM
c. CDRL 12038 – Test Tool SUM
d. CDRL 12039 – Software Programmer's Manual
e. CDRL 12042 – Computer System Operator's Manual
f. CDRL 12045 – Firmware Support Manual
g. CDRL 14007 – ITWS System Technical Instruction Books (TIBs)
h. CDRL 14035 – Test Tool TIBs

4.1.2.2.7.1.4 Data Analysis Methods.

Discrepancies identified during test conduct resulted in PTRs which then became redline changes to the contractor documentation.

4.1.2.2.7.2 Subtest 2 – FAA Maintenance Handbook.

4.1.2.2.7.2.1 Test Objectives.

The objective of the FAA Maintenance Handbook test was to ensure that the tools and procedures necessary to conduct Certification, as well as those necessary to perform routine maintenance in accordance with the FAA Maintenance Handbook are readily available to the maintenance technician.

4.1.2.2.7.2.2 Test Criteria.

ITWS certification test procedures examined if ITWS system level and service level certification requirements can be accomplished during normal system operations.

4.1.2.2.7.2.3 Test Approach.

The certification procedures contained in the FAA Maintenance Handbook were performed to verify that the ITWS could be certified.

4.1.2.2.7.2.4 Data Analysis Methods.

Discrepancies identified during test conduct resulted in PTRs which then became redlines to the Handbook.

4.1.2.2.8 Training.

4.1.2.2.8.1 Test Objectives.

The objective of the Training evaluation was to determine the adequacy and effectiveness of both AT and AF training programs.

4.1.2.2.8.2 Test Criteria.

This assessment determined whether the users were adequately trained to use and maintain ITWS in the operational environment.

4.1.2.2.8.3 Test Approach.

Training schedules were reviewed to ensure that an adequate number of trained and certified personnel were available to operate the ITWS. A questionnaire, which assessed all aspects of the training programs, was developed by ACB-630. Training was evaluated against the following training suitability test issues:

Scheduling: Were a sufficient number of trained personnel available to operate ITWS and to perform maintenance functions and to accomplish system analysis?

Effectiveness: Was training sufficient to provide adequate performance of use/ maintenance functions?

Follow-On Training: Has planning for necessary follow-on training been initiated as required?

4.1.2.2.8.4 Data Analysis Methods.

Questionnaire responses were recorded and entered into spreadsheets. Various statistical calculations were conducted along with accompanying graphical representations.

4.1.2.3 Operational Effectiveness.

Testing of ITWS operational effectiveness evaluated ITWS stress and NAS loading, operational requirements, degraded operations, transition switchover, site adaptation data, and security.

4.1.2.3.1 Stress and NAS Loading.

4.1.2.3.1.1 Test Objectives.

The objective of the Stress and NAS Loading testing was to evaluate the operational performance capabilities of ITWS under stress and loading scenarios. In particular, the ORD capacity requirements were verified.

4.1.2.3.1.2 Test Criteria.

This evaluation determined whether the ITWS could support the maximum operational performance described in the ORD.

4.1.2.3.1.3 Test Approach.

The operational performance of ITWS was evaluated at each OT site utilizing an AOS-250 generated Worst-case Test Scenario data tape that provided a maximum stress environment on the ITWS. ACB-630 used Raytheon's Developmental Testing (DT) to verify the maximum interface configuration since none of the First Article OT sites (Technical Center, Kansas City, Houston) provided either all possible interfaces (LLWAS III was not available) or the maximum number of interfaces (Houston had two ASR-9s and two TDWRs). Some of these requirements could only be verified by ACB-630 witnessing DT testing and analyzing resulting test reports.

The Worst Case scenario was designed to maximum data conditions on the ITWS system for a maximum period of three consecutive hours.

4.1.2.3.1.4 Data Analysis Methods.

The CPU, memory, and disk space utilizations were periodically logged to a file during test conduct. This file then was analyzed to determine peak and average utilizations.

4.1.2.3.2 Operational Requirements.

4.1.2.3.2.1 Test and Evaluation Objectives.

Operational Requirements testing was conducted to determine that ORD requirements were met under operational conditions. The majority of these requirements are related to meteorological performance. These requirements were tested at the first article sites, to mitigate risks associated with system performance under different climatological conditions. Not all of these meteorological performance requirements were tested during OT.

4.1.2.3.2.2 Test and Evaluation Criteria.

Testing required an active meteorological weather pattern. Although some tests can be run under "clear air" conditions, the majority of the tests were designed for adverse climatological conditions. For meteorological validation, meteorologists were used to qualitatively evaluate the individual input data displays against the ITWS SD providing a subjective determination of consistency between the input and output data. Individual ITWS interfaces were monitored to ensure that operational systems were not degraded by virtue of being connected to the ITWS. ACB-630 conducted all or a subset of these tests at each of the First Article sites and continued evaluations, if necessary, at the Technical Center after completion of testing at the last First Article site.

At issue, also was the testability of some of the ORD meteorological performance requirements. Due to the way that many of these requirements are stated in the ORD, testing was not feasible within the given time and fiscal constraints. These ORD requirements are currently being re-written to more accurately reflect the testing that could be accomplished. By mutual consent between ATB-200, ACB-630, and Massachusetts Institute of Technology/Lincoln Laboratory (MIT/LL), prior results from prototype evaluations and Raytheon DT testing were accepted as evidence that many of these requirements are met by the ITWS system.

4.1.2.3.2.3 Test and Evaluation Approach.

The meteorological tests performed compared the ITWS output against the displays of the input data. A qualitative visual comparison between the ITWS SD and the NEXRAD, ASR-9, TDWR Display Functional Unit (DFU) and base data displays were performed to verify the accuracy of the ITWS SD. While the ITWS uses a collaboration of all available inputs, the ITWS SD should present weather data within a close proximity to those viewed on the individual sensor displays.

4.1.2.3.2.4 Data Analysis Methods.

ORD, Minimum Acceptable Operational Performance Requirement (MAOPR), and COI requirements pertaining to Meteorological Performance were validated through quantitative and comparative analysis. Quantitative evaluations involved the transparent recording of input data and the use of off-line data analysis tools to compare ITWS derived products. ITWS products were evaluated against TDWR DFU, TDWR Base data, NEXRAD Associated Principal User Processor (APUP), and ASR-9 displays to validate the reasonableness of ITWS product output, and latency of the ITWS product display. These evaluations were conducted at the test facilities with minimal impact to facility operations.

Although meteorological performance validations have been performed with recorded and synthetic data sets, Operational Testing was performed with live input sensors and systems. The meteorological evaluations continued at the Technical Center throughout ITWS First Article and Production testing. Some of the meteorological requirements were deemed not testable given the constraints of OT testing; many of these requirements are being rewritten as a part of the updated ORD.

4.1.2.3.3 Degraded Operations.

The Degraded Operations test evaluated the ability of ITWS to tolerate and respond to a variety of failures under normal and stress load conditions. Subtests included evaluation of interface failures, power failures, and degraded system operations. The induced failures included power failures, hardware failures and software failures for ITWS components and equipment interfaced to ITWS. This testing verified that after the system had been subjected to a failure, the ITWS and NAS subsystems produced the expected response, a mechanism to recover from the failure was established, and the failure was reported to the MDT position.

4.1.2.3.3.1 Subtest 1 – Interface Failure Test.

4.1.2.3.3.1.1 Test Objectives.

In order to generate its products, ITWS is dependent on its sensor and weather model inputs. Depending on the input lost, a given product may be determined to be unavailable or available in a degraded (but acceptable) condition. This test evaluated the effect that failed interfaces had on the ITWS.

4.1.2.3.3.1.2 Test Criteria.

ITWS must continue to operate after responding to single and multiple interface failures without causing any degradation of the existing ATC NAS Subsystem. ITWS must also report the failures accurately and in a timely manner and transition to the proper mode if appropriate.

4.1.2.3.3.1.3 Test Approach.

To perform this test, various inputs to the ITWS PG were removed and the output of the PG was evaluated (including determination of the proper operating mode). Also, appropriate product display on the SD and Ribbon Display Terminals (RBDTs) was also verified. Single and multiple faults were induced. The operation of the system was evaluated during the period from fault insertion to recovery.

4.1.2.3.3.1.4 Data Analysis Methods.

The induced failure(s) were used to verify the ability of the ITWS to recognize the failure, display appropriate products, recover from the failure, and report events to the MDT position. The SD, System Event Message (SEM) Log, and MDT were observed for the proper actions, display and reporting of failures.

4.1.2.3.3.2 Subtest 2 – Power Failure Test.

4.1.2.3.3.2.1 Test Objectives.

The objective of the Power Failure Test was to evaluate the ability of the ITWS to recover from power failures.

4.1.2.3.3.2.2 Test Criteria.

In case of a power failure, ITWS must be capable of being brought back to operational status in a timely manner.

4.1.2.3.3.2.3 Test Approach.

To perform this test, various subsystems were powered 'OFF' for varying time durations (i.e., SD, UCONX concentrator, etc.) and the output of the PG was evaluated. In addition, the PG was subjected to power failures for varying time durations and ITWS recovery (initialization) to the proper mode was evaluated.

4.1.2.3.3.2.4 Data Analysis Methods.

The induced failure(s) were verified via alerts displayed on the SD and MDT.

4.1.2.3.3.3 Subtest 3 – Subsystem Degraded Operations Test.

4.1.2.3.3.3.1 Test Objectives.

The objective of the Subsystem Degraded Operations Test was to evaluate the effect that failed interfaces had on the ITWS, and that the loss of individual interfaces did not degrade the overall ITWS system performance. Depending on the input lost, a given product may be determined to be unavailable or available in a degraded (but acceptable) condition. The ITWS was evaluated to determine that it reacted appropriately per specification) when individual interfaces were failed or lost.

4.1.2.3.3.3.2 Test Criteria.

ITWS must be capable to continue operating after responding to single and multiple subsystem failures without causing any degradation of the existing NAS Subsystem. ITWS must also report the failures accurately and in a timely manner and transition to the proper mode.

4.1.2.3.3.3.3 Test Approach.

To perform this test, various ITWS subsystem internal components were removed and the output of the PG was evaluated (including determination of the proper operating mode). Also, appropriate product display on the SD and RBDTs was also verified. Single and multiple faults were induced. The operation of the system was evaluated during the period from fault insertion to recovery.

4.1.2.3.3.3.4 Data Analysis Methods.

The induced failure(s) and the effects on the ITWS were verified via SD and MDT.

4.1.2.3.4 Transitions Switchover.

4.1.2.3.4.1 Test Objectives.

Transition Switchover Testing was conducted to assess the effectiveness of the phased transition of the operational site from the TDWR environment to the ITWS environment.

4.1.2.3.4.2 Test Criteria.

This evaluation assessed whether adequate procedures to transition from TDWR to ITWS had been developed. It also was used to identify AT issues resulting from the differences in the TDWR and ITWS (TDWR mode) displays that may affect this transition.

4.1.2.3.4.3 Test Approach.

The transition procedure was used at each key site to simulate a transition from TDWR to ITWS. In the event that dual TDWR and ITWS operations were utilized, ACB-630 verified that transition from TDWR to ITWS and vice versa had minimal impact on AT operations. Also, users from ITWS prototype sites and TDWR sites identified transition issues based on TDWR and ITWS display differences.

4.1.2.3.4.4 Data Analysis Methods.

An AT questionnaire was used to determine a) how much impact the transition has on perceived workload; and b) if there are any tasks that are hindered by the transition.

The questionnaire data were gathered and presented similarly. The data were separated both by position (TMC, SUP, etc) and by facility (tower, TRACON) to determine any discrepancies associated with the use of the products or display that were peculiar to a specific position or facility.

4.1.2.3.5 Site Adaptation Data.

4.1.2.3.5.1 Test Objectives.

Site Adaptation Tests were conducted on the Site-Specific Adaptation Data through inspection of the ITWS site database. Field-Settable and User-Settable Adaptation Data also was verified. The ITWS adaptation data collectively consists of over 1.5 megabyte (Mb) of binary data.

Field-Settable Adaptation Data was modified at the MDT or SD, as appropriate. The alteration of field-settable adaptation data was considered a maintenance function, except for the display support commands and their associated data (i.e. change password, set runway control, and edit RBDT alarm time outs).

User-Settable Adaptation Data was modified at a SD as an operational capability, not a maintenance action. Changes affect only the SD at which the changes are entered. The User-Settable parameters consist of the parameters that control the SD window configuration.

4.1.2.3.5.2 Test Criteria.

The Site-Specific Adaptation Data was employed to set system-wide and site-specific parameters and evaluated to ensure that it matched the data provided by the government for each key site. Field-Settable Adaptation Data were changeable by field personnel and assigned a default value (where appropriate). User-Settable Adaptation Data were changeable by field personnel and these changes can be saved. Inappropriate adaptation data changes (e.g. attempts made to change adaptation by unauthorized users) were attempted, and failures noted.

4.1.2.3.5.3 Test Approach.

For each key site, the site data provided by the government were compared to the Site-Specific Adaptation Data in the ITWS site database. Attempts were made to modify each of the Field-Settable Adaptation Data parameters at the MDT and SD, as appropriate. Those with acceptable ranges were exercised for range validation and error notification. Each of the User-Settable Adaptation Data parameters were modified at the SD and saved; the saved versions were verified.

4.1.2.3.5.4 Data Analysis Methods.

The ITWS response to changes in Field- and User-Settable Adaptation Data were recorded. It was then verified that the changes had been retained after a reboot and a power cycle.

4.1.2.3.6 Security.

4.1.2.3.6.1 Test Objectives.

The objective of the security test was to demonstrate that the ITWS system has appropriate operational security procedures in place. In an operational setting, these include procedures to restrict access to the workstation by requiring specific user log-ins and passwords. Tests verified that operators' classes were specified and adaptable. It also verified that the sources of all data entering the system were validated.

4.1.2.3.6.2 Test Criteria.

This test verified that specified security features had been implemented at the ITWS test sites. These security features a) limit user level authority, b) prevent unauthorized system entry via system safeguards, c) maintain an automated audit log that records all attempts to access the system, and d) prevent unintentional system shutdown. An audit trail was maintained and password-protected, accessible only by authorized users.

4.1.2.3.6.3 Test Approach.

Employing user logins and passwords, it was verified that unauthorized users were denied access to certain ATC functions and that only a specific user can modify passwords. Logins with passwords were tested. Incorrect IDs, passwords, and combinations were entered. The functions allowed to the user were verified. The audit trail was examined by an authorized user to determine accuracy. An unauthorized user attempted to access, modify, and destroy the audit log.

4.1.2.3.6.4 Data Analysis Methods.

A security checklist was used to collect the aforementioned security data. This checklist was performed on each piece of ITWS equipment (e.g., SD, PG, NFU). The checklists were inspected and failures resulted in PTRs.

4.1.2 Data Collection and Analysis.

Data collection and analysis are described in section 4.1.2 for individual tests.

4.1.3 Technical Center Results.

Table 4.1.4-1 presents the results of the Technical Center testing, and the number of failed and deferred requirements.

TABLE 4.1.4-1 TECHNICAL CENTER TEST RESULTS

Test Name	Total # Reqts	# Reqts Deferred	# Reqts Tested Technical Center	# Reqts Failed
ASR-9	37	16	21	0
ADAS	69	0	69	1
FBWTG	36	1	35	9*
NEXRAD	1	0	1	0
TDWR-PG	44	3	41	12*
TDWR-SD	76	8	68	43*
DLU	14	0	14	1
NAS	14	0	14	3
Response Times	25	0	25	0
Interoperability	None	0	0	0
Human Factors	15	0	15	0
Logistics	5	0	5	0
Training	1	0	1	0
Stress Load	3	0	3	0
Operational Reqt**	46	29	17	0
I/F Failure	3	0	3	0
Power Failure	None	0	0	0
SubSys Deg Ops	3	0	3	2
Site Adaptation	2	0	2	0
	515	178	337	71*

Note: The "% Reqts Failed" column has been calculated using the number of requirements actually tested at the Technical Center ("# Reqts Tested Technical Center"), rather than the "Total # Reqts".

* - 64 of the 71 failures are TDWR and FBWTG IRD discrepancies. Once the IRDs have been updated to reflect current implementation, the designation of these failures will change to "passed", thus make the effective failure rate for the Technical Center First Article OT equal to 2.7%.
** -This test was partially deferred

The CRITICAL Technical Center DRs have been addressed as follows:

a. FTC-11 refers to the lack of identification on the ASR-9 cables, allowing for the possibility of incorrect installation, without the ITWS system realizing it. This DR is closed.

b. FTC-15 refers to the NEXRAD test pattern being displayed on the ITWS SD during periods of NEXRAD maintenance. The problem is the ITWS PG recognizes the test pattern as real data, and processes and displays it accordingly. This DR is closed, based on training.

c. FTC-46 refers to the non-retention of archive data. This DR has been resolved and closed.

d. FTC-49 refers to incorrect runway overlay maps. This was an adaptation data change, which was affected by Raytheon, thus closing the DR.

e. FTC-100 refers to the lack of availability of TDWR windshear products under certain conditions. If the output of the TDWR RPG to ITWS PG is lost, ITWS will continue to display all other available ITWS products. However, by automatically transitioning to TDWR backup mode, AT users would have access to the TDWR windshear products. Without this automatic transition, AT will be left without the TDWR safety products, when in fact they are readily available to them. This DR remains open, awaiting ARU concurrence that Raytheon should implement a solution. It may be closed by making it a training issue.

f. FTC-105 refers to the untestability of a number of the ORD meteorological requirements. This DR will be closed upon the publication of the updated ORD.

g. FTC-107 refers to the UCONX recycling upon the loss of a single circuit. This DR has been resolved and closed.

h. FTC-119 refers to the SD timing out after archiving. Raytheon implemented a solution and this DR is closed.

4.2 PHASE II – KANSAS CITY.

Phase II OT took place at MCI from August 15 – October 18, 2001. OT was conducted in the ATCT and TRACON at MCI and at ZKC; a TRACON SD was installed in the MCI training room, which allowed for TRACON testing to be conducted, while minimizing the intrusion in the TRACON spaces.

4.2.1 Test Objective.

Phase II OT at MCI focused more on operational and field interface verification. The primary objectives of Phase II OT were: 1) to examine ITWS operational performance characteristics at both simple and complex (multiple ASR-9 and TDWR inputs) sites to ensure ITWS can be integrated into the NAS without degradation of existing sensor performance, and 2) to determine that ITWS products and displays are useful to AT personnel. While NAS interfaces were utilized at the Technical Center, there are significant inherent differences between an operational field site installation and a laboratory installation, such as that at the Technical Center Weather Laboratory. Phase II focused more on operational and field interface verification.

As in Phase I, LLWAS III was unavailable, therefore, not tested. As described in section 4.2.5, human factors testing was conducted, but limited in some respects.

4.2.2 Test Description.

The descriptions of the tests conducted are similar to those described in section 4.1.2.

4.2.3 Data Collection And Analysis Method.

Data collection and analysis methods are similar to those described in section 4.1.3.

4.2.4 Results/Discussion.

Table 4.2.4-1 presents the results of the individual tests conducted at MCI, as well as the number of failed requirements. Eight of the sixty DRs that were generated during testing were designated as critical; one remains open. A full description of the Kansas City DRs is contained in appendix A.

TABLE 4.2.4-1 MCI OT TEST RESULTS

Test Name	Total # Reqts	# Reqts Not Tested	# Reqts Tested MCI	# Reqts Failed
ASR-9	55	0	54	34
DLU	14	0	14	0
NAS	14	0	14	0
Response Times	2	1	1	0
Sys Stability	None	--	--	--
Reliability/Avail	3	0	3	0
Maintainability	6	5	1	0
Operational Reqts	17	0	17	3
I/F Failure	3	0	3	0
Transition Switch	None	--	--	--
Site Adapt	2	0	2	0
Total	116	6	76	37

The CRITICAL MCI DR’s have been addressed as follows:

a. MCI-4 refers to the possible confusion that may result from viewing weather on the SD that is generated by different sensors. The inherent differences in the input sensors (update rates, elevation angles, beam patterns, sensor location, etc.) will most likely cause differences in the displayed weather; this is a training issue, and thus is closed.

b. MCI-5 is related to placing the ITWS PG on the critical power bus. This was implemented during Production ITWS installation, thus this DR is closed.

c. MCI-6 refers to the problems encountered when viewing the Tower SD in bright sunlight. This problem was solved by virtue of utilizing flat panel LCD SDs, which are a part of the standard Production ITWS installation, thus this DR is closed.

d. MCI-7 refers to the excessive brightness of the SD, when being rebooted; the white screen that ensues is unacceptable in the TRACON environment. This DR was closed by virtue of Raytheon reversing the display technique during reboot (black screen with white characters).

e. MCI-43 refers to TWIP data being generated by ITWS (instead of TDWR). If the ITWS PG were to fail, TWIP data would be unavailable. ARU has stated that this is acceptable, considering the minimal amount of time that ITWS is expected to be unavailable. TWIP data is not critical enough to warrant further action.

f. MCI-51 refers to the appearance of windshear icons on the SD during clear weather. This DR has been closed after implementation of Raytheon STR-7566.

g. MCI-60 is related to the problem with running the TDWR Weather Scenario Tape during quarterly TDWR certification. When the TDWR is placed into maintenance mode in order to running the weather tape, the output link is disabled, thus the output is not viewable on the ITWS SDs. When the Geographic Situation Displays (GSDs) are removed (i.e. replaced with SDs) there will be no means of certifying the TDWR output. This is being addressed by AOS-250; a possible solution would be to certify the TDWR at the RPG using a GSD.

h. MCI-62 refers to the Tornado product. When the NEXRAD detects a Tornado Vortex Signature (TVS), ITWS was actually calling this a Tornado and placing the icon on the SD, thus causing false alarms. This DR has been closed by virtue of the terminology being changed from Tornado to TVS, the elimination of this message from the RBDT, and ensuring that the issue is addressed during training.

4.2.5 Human Factors Evaluation.

The Human Factors evaluation was conducted for the MCI ITWS sites. These sites included the MCI TRACON and ATCT. Users at ZKC were not assessed as they had yet to receive training regarding the use of the ITWS. The purpose of the data collection was to capture information regarding the operational utility, ease of use, and type of use of the ITWS during convective weather at MCI. The Technical Center evaluators assessed ITWS using various demonstration techniques, including questionnaires, interviews, and workload scales. Detailed data and results are contained in appendix D.

4.2.5.1 Questionnaires.

Questionnaire results regarding the ITWS products and functionality are summarized in appendix D, table D-1 for all users for each product feature. The rating scale is defined under the table. In general, users rated the products favorably. With the exception of the Automated Terminal Information Service (ATIS) Countdown Timer, all products and functions were rated as frequently to consistently enhancing job performance on the dimensions of utility, ease of use, and readability. The ATIS Countdown Timer received a neutral utility rating indicating that it neither enhanced nor hindered job performance. It should be noted that while the Tornado product received a median rating of 2 (Frequently Enhances), 3 out of the 7 users rated it as a 5 (Consistently Hinders).

Meteorological interpretation results regarding the ITWS products are summarized in appendix D, table D-2 for all users. In general, users rated the products favorably. With the exception of SEP and Tornado, all products were rated as completely acceptable. The Storm Extrapolated Position and Tornado products received a rating of reasonably acceptable; however, 3 out of 7 users rated the Tornado product as completely unacceptable.

4.2.5.2 Workload.

The prescribed method of data collection is to assess user workload prior to implementation of the new system, in order to establish a baseline. Workload is assessed again after users have evaluated the system for a representative period of time. This was not possible in Kansas City because users were exposed to the ITWS prior to baselining for the workload assessment. In this case, users were questioned about pre- and post- ITWS usage simultaneously. While this is not the prescribed method, the validity of this data has been corroborated by its similarity to the data collected in Houston, as well as previous prototype site data collections. The MCI results are included herein, for the sake of comparison to similar data collected previously at the prototype sites, and Houston. The Wilcoxon Signed Ranks Test, a non-parametric test of significance, was used to determine the statistical significance between the pre and post ITWS scores for each task. A two-tailed probability of significance was set at the .05 level.

The Modified Cooper Harper (MCH) mental workload scale was used to measure overall perceived user mental workload as it applied to operational use of the ITWS for specific air traffic tasks. The 10-point workload scale rating definitions ranged from:

a. 1 - very easy, highly desirable. Operator mental effort is minimal and desired performance is easily attainable, to

b. 10 - Impossible. Instructed task cannot be accomplished reliably.

Lower rating scores indicated lower perceived workload in performance of any of the identified tasks during a convective weather event. Conversely, higher scores indicated greater perceived workload.

Comparisons between MCI TRACON users' MCH scale pre-and post-workload analysis showed that perceptions of operator mental workload decreased after introduction of ITWS for all task areas with the exception of choosing runways. It should be noted that avoiding adverse weather was the only task area of the six evaluated, to show a statistically significant decline in workload with the introduction of ITWS. Results are contained in appendix D, figure D-1.

4.2.5.3 Comments.

Comments received in the open-ended questions in this section of the questionnaire addressed the perceived unreliability of the tornado product, the tower SD visibility, and some difficulties with the Storm Cell Information product; in general, however, the comments tended to a favorable disposition toward the ITWS. The Tornado and tower SD issues were previously captured as DRs and subsequently resolved.

4.3 PHASE III – HOUSTON.

Phase III OT took place at IAH from October 4 through November 12, 2001. Testing was conducted in the ATCT at IAH and HOU, the TRACON at I90, and ZHU.

4.3.1 Test Objective.

Phase III OT at I90 continued the focus of Phase II with emphasis placed on complex site performance. This was the first ITWS site with multiple ASR-9s and TDWRs. As at the Technical Center and MCI, the LLWAS III was not available, and remained untested. Human factors evaluations were conducted at IAH, including Workload Study.

4.3.2 Test Descriptions.

The descriptions of the tests conducted are similar to those described in section 4.1.2.

4.3.3 Data Collection And Analysis Method.

Data collection and analysis methods are similar to those described in section 4.1.3.

4.3.4 Results/Discussion.

Table 4.3.4-1 presents the results of the individual tests conducted at IAH as well as the number of failed requirements. Three of the twenty-eight DRs that were generated during testing were classified as critical; all have been closed. A full description of the Houston DRs is contained in appendix A.

Requirements for the PG to communicate to multiple ARTCC SDs and for an ARTCC SD to communicate with multiple PGs were partially satisfied for the first time. The MCI and I90 PGs communicated with the ZKC SD, ZHU SD, and ZTC SD (at the Technical Center), thus proving single PG to multiple ARTCC SD functionality. The FTC SD ingested and simultaneously displayed ITWS products from the Technical Center, MCI, and I90 PGs, thus demonstrating the ability for an ARTCC SD to communicate with multiple PGs. The I90 PG also demonstrated the ability to ingest sensor data, and generate airport-specific TWIP products for two airports (IAH and HOU) simultaneously.

TABLE 4.3.4-1 I90 OT TEST RESULTS

Test Name	Total # Reqts	# Reqts Not Tested	# Reqts Tested I90	# Reqts Failed
DLU	14	0	14	0
NAS	14	0	14	0
Response Times	2	1	1	0
Sys Stability	None	--	--	--
Reliability/Avail	3	0	3	0
Operational Reqts	17	0	17	3
Site Adapt	2	0	2	0
RMMS		deferred		
Other				
Total	52	1	51	3

The CRITICAL IAH DRs have been addressed as follows:

a. IAH-22 refers to the large number of CPU Utilization Alarms and Alerts reported by the MDT during severe weather in Houston. CPU and memory capabilities upgrade in the Production ITWS appears to have corrected this problem. This DR was closed.

b. IAH- 27 refers to discrepancies between the ITWS driven RBDT and the TDWR driven RBDT. TDWR reported a windshear on the runway and ITWS reported it at 3 mile final. Raytheon is investigating this issue; the answer may be due to the differences between the TDWR and ITWS algorithms. Since this discrepancy has not been duplicated, the DR is considered closed.

c. IAH-29 refers to the need to update the Houston adaptation data to reflect an impending runway change. Raytheon provided updated adaptation data prior to the runway change, thus closing the DR.

4.3.5 Human Factors Evaluation.

The Human Factors evaluation was conducted at the IAH TRACON, IAH ATCT, HOU ATCT, and ZHU. The purpose of the data collection was to capture information regarding the utility, ease of use, and type of use of the ITWS during convective weather at Houston. The FAA Technical Center evaluators assessed ITWS using various demonstration techniques, including questionnaires, interviews, and workload scales. Detailed data and results are contained in appendix D.

4.3.5.1 Questionnaires.

Questionnaire results regarding the ITWS products and functionality are summarized in appendix D, table D-3 for all terminal users of each product feature. In general, users rated the products favorably. With the exception of the ATIS Countdown Timer, all products and functions were rated as frequently to consistently enhancing job performance on the dimensions of utility, ease of use, and readability. The ATIS Countdown Timer received a neutral utility rating indicating that it neither enhanced nor hindered job performance.

Questionnaire ranking results regarding the ITWS products and functionality are summarized in appendix D, table D-4 for each ARTCC user group for each product feature. In general, TMU users rated the products favorably. With the exception of the ATIS Countdown Timer and the Ribbon Display Terminal, all products and functions were rated as frequently to consistently enhancing job performance on the dimensions of utility, ease of use, and readability. The ATIS Countdown Timer and RBDT received a neutral utility rating indicating that they neither enhanced nor hindered job performance. These products also received borderline ease of use and readability ratings indicating that users felt minor changes would make them more useful. The users did not suggest specific changes.

CWSU users rated the Long Range Precipitation, Lightning, ATIS Countdown Timer, and Tornado products, as well as the Pan feature, as neutral indicating that they neither enhanced nor hindered their job performance. The remaining products and features received utility ratings of frequently enhancing job performance or better. The Pan feature received a borderline rating for ease of use and readability rating indicating that users felt minor changes would make it more useful. The Lightning product received a borderline rating for ease of use. The users did not suggest specific changes.

Meteorological interpretation results regarding the ITWS products are summarized in appendix D, table D-5 for all terminal users. In general, users rated the products favorably. Most products were rated as completely acceptable with the precipitation products rated as reasonably acceptable.

Meteorological interpretation results regarding the ITWS products are summarized in appendix D, table D-6 for all ARTCC users. In general, both user groups rated the products favorably. With the exception of Tornado, all products were rated as reasonably or completely acceptable. The Tornado product received a rating of moderately unacceptable by CWSU users. CWSU users indicated that the Tornado product could be misleading to non-meteorologists, as they would not be aware of the products limitations.

4.3.5.2 Workload.

The prescribed method of data collection is to assess users prior to implementation of the new system, in order to establish a baseline. Workload is assessed again after users have employed the system for a representative period of time. The Wilcoxon Signed Ranks Test, a non-parametric test of significance, was used to determine the statistical significance between the pre and post scores for each task. A two-tailed probability of significance was set at the .05 level.

See section 4.2.5.2 for a description of the Workload scale.

Comparisons between Houston Terminal users' MCH scale pre-and post-workload analysis showed that perceptions of operator mental workload decreased after the introduction of ITWS for all task areas. Of the six tasks assessed, four showed statistically significant decline in workload. Two tasks, planning air traffic flow and planning airspace use, showed declines in workload, however they were not statistically significant. appendix D, figure D-2 shows the pre- and post-ITWS median ratings for each task.

Comparisons between ZHU ARTCC users' MCH scale pre-and post-workload analysis indicated that for all task areas, perceptions of operator mental workload showed no change after introduction of ITWS. Appendix D, figure D-3 shows the pre- and post-ITWS median ratings for each task.

5. SUMMARY OF CONCLUSIONS.

Phase I Operational Test (OT) testing at the Technical Center afforded the opportunity to evaluate the Integrated Terminal Weather System (ITWS) utilizing equipment and interfaces that were consistent with an operational configuration, but without interfering with local Air Traffic (AT) and Airway Facilities (AF) operations and personnel. Problem identification and resolution were conducted in a timely and cost efficient manner without the limitations imposed by an operational facility. Problems and discrepancies were recorded (appendix A) and responsibility for resolution assigned; in the cases where Raytheon was responsible for problems, they were notified, and in most cases, the problems resolved.

The hands-on time with the ITWS system, in a controlled environment (the ACB-630 Weather Laboratory versus a TRACON installation in the field) provided the opportunity to refine the system and to field a more stable system when it was installed at operational facilities (Kansas City and Houston). It also provided Raytheon with an expedient and economical means of problem solving and demonstration to ACB-630. The leased T1 communications line between Raytheon and the Technical Center proved to be indispensable due to the limitations of the ITWS Maintenance Data Terminal (MDT) as a diagnostic tool. This line was also used to trouble-shoot system software problems. Raytheon personnel visits to the Technical Center were significantly reduced and problems were effectively diagnosed and resolved.

Based on First Article OT (Phase I, II, and III) testing, the following conclusions have been reached:

a. The ITWS MDT requires modifications if it is to be a useful tool for AF personnel. The limited circuit status visibility and misleading status indicators will present problems to AF users and delay problem resolution. AF users receive no Maintenance Processor Subsystem (MPS) status information on the MDT.

b. While having the ability to process and display precipitation data from three different weather radars gives the ITWS flexibility and a needed redundancy, some users felt that viewing precipitation products from all three radars simultaneously could present conflicting information, and consequently could cause operational problems. The Kansas City International Airport (MCI) AT users did not cite specific examples of how this presented a problem during OT; they presented it as a possible problem. It should be noted that prototype users in Orlando, Memphis, New York, and Dallas have had access to the same products since 1993, and have yet to identify the multiple radar presentation as a problem.

c. During OT testing it was noted that when the ITWS Situation Display (SD) replaces the Terminal Doppler Weather Radar (TDWR) Geographic Situation Display (GSD), a new means of certifying the TDWR would be required, since the TDWR certification data is not transmitted to the ITWS SD.

d. Many of the Discrepancy Reports (DRs) that were written pertain to differences between the ITWS design and the requirements documentation. Many of the Interface Requirements Documents (IRDs) are no longer valid, with respect to ITWS.

Human Factors evaluations were conducted as part of Phases II and III OT. Conclusions for these evaluations are as follows:

a. Based on interviews, users noted that the Gust Front, Terminal Winds, Storm Motion, and Precipitation products were most useful for AT tasks.

b. With the exception of the Automated Terminal Information Service (ATIS) Countdown Timer, all products and functions were rated as frequently to consistently enhancing job performance on the dimensions of utility, ease of use, and readability. The ATIS Countdown Timer received a neutral utility rating.

c. While the tornado product received a median utility rating of frequently enhancing job performance, many of the users indicated that the product needs to be reviewed for accuracy.

d. With the exception of Storm Extrapolated Position (SEP) and Tornado, all products were rated as completely acceptable for meteorological interpretation. The SEP and Tornado products received a rating of reasonably acceptable. Again, users noted that the Tornado product needs to be reviewed for accuracy.

e. MCI terminal workload results showed that the perceived workload decreased with the introduction of ITWS for all tasks except Choosing Runways. However, of these tasks, Avoiding Adverse Weather is the only task to show a statistically significant decline in perceived workload. Houston terminal workload results showed that the perceived workload decreased after the introduction of ITWS for all tasks. Of these tasks, Decisions on Rerouting Aircraft, Avoiding Adverse Weather, Choosing Runways, and Changing Runways showed statistically significant declines in perceived workload.

f. Air Route Traffic Control Center (ARTCC) workload ratings did not indicate a reduction change in workload with the introduction of ITWS for all task areas tested.

6. RECOMMENDATIONS.

ACB-630 made the following recommendations based on the completion of First Article OT:

a. ACB-630 recommends early human factors involvement in the development of future MDT designs, in order to ensure that the ITWS meets the needs of the AF community. An MPS connection status light/button should be included on the MDT. .At a minimum, the production maintenance concept (for TCP/IP) should include fundamental maintenance tools such as “ping” functions and the Simple Network Management Protocol (SNMP).

b. Differences in the precipitation products displayed at various ranges are due in large part to the inherent differences between the radars (location, beam pattern, update rate). Training should stress the differences between the 3 radars used to present ITWS products, thereby decreasing any confusion.

c. The capability to certify the TDWR will be lost when the ITWS SD replaces the TDWR GSD. A certification procedure must be developed that will allow TDWR certification via both the ITWS Product Generator (PG) and the ITWS SD.

d. All IRDs should be updated to reflect the current implementation.

e. Follow-on human factors evaluations should be conducted, to ensure continued user satisfaction with the ITWS SD and products.

7. ACRONYMS.

ACY	Atlantic City International Airport
ADAS	AWOS Data Acquisition System
ADNS	ARINC Data Network Services
AF	Airway Facilities
AFSS	Automated Flight Service Stations
AP	Anomalous Propagation
APUP	Associated Principal User Processor
ARINC	Aeronautical Radio Incorporated
ARTCC	Air Route Traffic Control Center
ASCII	American Standard Code for Information Interchange
ASOS	Automated Surface Observing System
ASR-9	Airport Surveillance Radar-Model 9
AT	Air Traffic
ATC	Air Traffic Control
ATCT	Air Traffic Control Tower
ATCSCC	Air Traffic Control System Command Center
ATIS	Automated Terminal Information Service
ATL	Atlanta Hartsfield International Airport
ATN	Aeronautical Telecommunications Network

AWOS	Automated Weather Observing System
BWM	Bandwidth Manager
COI	Critical Operational Issue
CWSU	Center Weather Service Unit
DFU	Display Functional Unit
DLU	Data Link User
DR	Discrepancy Report
DT	Developmental Testing
FBWTG	FAA Bulk Weather Telecommunications Gateway
GFE	Government Furnished Equipment
GSD	Geographic Situation Display
HOU	Houston Hobby Airport
IAH	Houston George Bush Intercontinental Airport
IP	Internet Protocol
IRD	Interface Requirements Document
ITWS	Integrated Terminal Weather System
I90	Houston TRACON
LAN	Local Area Network
LLWAS	Low Level Windshear Alert System
MAOPR	Minimum Acceptable Operational Performance Requirement
Mb	megabyte
MCH	Modified Cooper Harper
MCI	Kansas City International Airport
MDCRS	Meteorological Data Collection and Reporting System
MDT	Maintenance Data Terminal
MIT/LL	Massachusetts Institute of Technology/Lincoln Laboratory
MPS	Maintenance Processor Subsystem
MTBF	Mean Time Between Failures
MTTR	Mean-Time-To-Repair
NADIN II	National Airspace Data Interchange Network II
NAS	National Airspace System
NEXRAD	Next-Generation Weather Radar
NFU	NWS Filter Unit
NIMS	NAS Infrastructure Management System
NLDN	National Lightning Detection Network
nm	nautical mile
NWS	National Weather Service
NWSTG	NWS Telecommunications Gateway
OMO	One-Minute Observations
ORD	Operational Requirements Document
OT	Operational Test
PCT	Potomac Combined TRACON
PG	Product Generator
PHL	Philadelphia International Airport
PSF	Program Support Facility
PSN	Packet Switching Network

PTR	Program Trouble Report
RBDT	Ribbon Display Terminal
RMMS	Remote Maintenance Monitoring System
RPG	Radar Product Generator
RSCIP	Remote Surveillance Communications Interface Processor
RUC	Rapid Update Cycle
SAT	Site Acceptance Testing
SCS	System Control Software
SD	Situation Display
SEE	Software Engineering Environment
SEM	System Event Message
SEP	Storm Extrapolated Position
SLS	System Level Specification
SNMP	Simple Network Management Protocol
SUM	Software User's Manual
SUP	Supervisor
TCP/IP	Transmission Control Protocol/Internet Protocol
TDWR	Terminal Doppler Weather Radar
TEM	Test Evaluation Matrix
TEMP	Test and Evaluation Master Plan
TIB	Technical Instruction Book
TMC	Traffic Management Coordinators
TMU	Traffic Management Unit
TRACON	Terminal Radar Approach Control Facility
TVS	Tornado Vortex Signature
TWIP	Terminal Weather Information for Pilots
WSR-88D	Weather Surveillance Radar – 88 Doppler
ZDC	Washington DC ARTCC
ZHU	Houston ARTCC
ZKC	Kansas City ARTCC
ZNY	New York ARTCC
ZTL	Atlanta ARTCC

APPENDIX A

ITWS DISCREPANCY REPORTS

Discrepancy Status

Discrepancy#	Originator	Date Written	Status	Priority	Assigned	Title
Build:	1019/1032					
FTC-4	Steve Viveiros	2/20/2001	Closed STR7394	Type III	Raytheon	Site Configuration Errors
FTC-8	Tom Weiss	2/26/2001	Closed STR7395	Type III	Raytheon	TRACON Airspace not completely visible
FTC-10	Tom Weiss	2/26/2001	Closed	Type III	AT REQ	TWINDS Data Display
FTC-13	Gerry DiMassa	2/27/2001	Closed	Type III	AF REQ	NFU Alarms
FTC-28	John Kelley	2/27/2001	Closed STR7403	Type III	ACT-320	Observation - Edit Alphanumeric Alarm Period
FTC-29	John Kelley	2/27/2001	Closed	Type III	AT REQ	Observation - ASR Button
FTC-37	Jimmy "C"	2/28/2001	Closed STR7405	Type III	ACT-320	Runway Configuration
FTC-38	Pat Sugrue	3/1/2001	Closed STR7406	Type III	Raytheon	MBA/WSA PIREP Control
FTC-39	Jim Olivo	3/2/2001	Open	Type III	ATB-260	Purpose on MDT Interface Status indications
FTC-40	Jim Olivo	3/6/2001	Closed	Type III	ATB-260/AOS-250	Interface indicator colors on MDT at startup
FTC-43	Gerry DiMassa	3/8/2001	Closed	Type III	ATB-260/AOS-250	Adapt.- IP Addresses for the NFU, FBWTG, the router, and TDWR
FTC-46	Donne Wedge	3/14/2001	Closed STR7408	TYPE II	Raytheon	Non-Retention of Archive Data
FTC-47	Donne Wedge	3/14/2001	Closed STR7409	Type III	Raytheon	Inconsistent Adaptation Data Reference
FTC-48	Tom Weiss	3/15/2001	Closed STR7410	Type III	AT REQ	TDWR Backup Mode - Long Range Selection
FTC-49	Gerry DiMassa	3/15/2001	Closed STR7411	TYPE I	AOS-250	Adaptation Configuration for runway overlay map incorrect
FTC-50	Jim Olivo	3/19/2001	Closed	Type III	AT REQ	Weather Observations
FTC-51	John Kelly	3/19/2001	Closed STR7412	Type III	AT REQ	OVERLAY Observations
FTC-52	Kool and the Gang	3/19/2001	Closed STR7413	Type III	AT REQ	Observations: System Performance
FTC-53	Tom Weiss	3/19/2001	Open STR7414	Type III	AT REQ	Overlay Box
FTC-55	Donne Wedge	3/21/2001	Closed	Type III	AT REQ	Sensor Status at SD
FTC-73	Gerry DiMassa	3/28/2001	Closed STR7486	Type III	ACT-320	TSAP ID's
FTC-74	Donne Wedge	3/28/2001	Closed	Type III	ATB-260	ADAS Adaptation Data
FTC-84	Donne Wedge	3/29/2001	Closed	Type III	ACT-320	ASOS/AWOS 4 Char Ids

Discrepancy#	Originator	Date Written	Status	Priority	Assigned	Title
FTC-85	Gerry DiMassa	3/29/2001	Closed	Type III	AT REQ	ITWS SD Terminal Text Display
FTC-87	Steve Viveiros	4/3/2001	Closed STR7438	Type III	Raytheon	Software Version Window
FTC-99	Donne Wedge	4/4/2001	Closed STR7450	Type III	ACT-320	Airport Site Adaptation Table
FTC-100	Bart Khatiwala	4/17/2001	Open	TYPE I	AT REQ	Wind Shear Products
FTC-101	Donne Wedge	4/17/2001	Closed STR7451	Type III	Raytheon	Unable to restore SD from Playback Mode
FTC-103	Gerry DiMassa	4/18/2001	Closed STR7453	Type III	Raytheon	Screen Saver on the MDT
FTC-104	Gerry DiMassa	4/18/2001	Closed STR7454	Type III	AT REQ	Terminal Text Function on the SD
FTC-107	Gerry DiMassa	4/27/2001	Closed STR7502	TYPE I	Raytheon	One Bad Circuit Causes the UCONX to ReCycle
FTC-108	Steve Viveiros	4/27/2001	Closed	Type III	ATB-260	TWINDs Coarse Analysis adapatation data
FTC-109	Steve Viveiros	4/27/2001	Closed	Type III	ATB-260	TWINDs Fine Analysis adapatation data
FTC-110	Steve Viveiros	4/27/2001	Open	Type III	ATB-260	TWIND Adaptation data
FTC-115	Jim Olivo	5/2/2001	Closed	Type III	AOS-250	PHL TDWR Basedata IP addressing
FTC-116	Jim Olivo	5/2/2001	Closed	Type III	ATB-260	Unavailability of FBWTG data after NFU outage
FTC-117	Jim Olivo	5/2/2001	Closed STR7566	Type III	Raytheon	False alarm rate exceeded
FTC-119	Steve Viveiros	5/2/2001	Closed STR7493	TYPE II	Raytheon	SD timeout after archiving

Build: 1026/1041

Discrepancy#	Originator	Date Written	Status	Priority	Assigned	Title
FTC-113	Donne Wedge	5/1/2001	Open	Type III	ATB-260	Unanticipated Impact of STR 7332
FTC-120	Steve Viveiros	5/3/2001	Closed	Type III	ATB-260	Input data recording
FTC-121	Steve Viveiros	5/3/2001	Closed	Type III	ATB-260	Product archiving
FTC-160	Steve Viveiros	5/17/2001	Closed STR7536	Type III	Raytheon	LLWAS interface
FTC-173	Steve Viveiros	5/24/2001	Open	Type III	ATB-260	No time range displayed for SD Archive Retrieval
FTC-174	Steve Viveiros	5/30/2001	Closed STR7558	Type III	Raytheon	Confusing problem description in SEM log

Build: N/A

Discrepancy#	Originator	Date Written	Status	Priority	Assigned	Title
FTC-3	Gerry DiMassa	2/20/2001	Closed STR7393	Type III	Raytheon	UconX identification
FTC-18	Gerry DiMassa	2/27/2001	Closed STR7397	Type III	ATB-260	ISO 7776, HDLC combined station
FTC-19	Gerry DiMassa	2/27/2001	Closed STR7397	Type III	ATB-260	Message format exchanges (appendix A)
FTC-30	Gerry DiMassa	2/28/2001	Open	Type III	Raytheon	TWIP ADNS Message Discrepancy

Discrepancy#	Originator	Date Written	Status	Priority	Assigned	Title
FTC-31	Gerry DiMassa	2/28/2001	Open	Type III	Raytheon	Typographical error on airport code mnemonic
FTC-32	Gerry DiMassa	2/28/2001	Open	Type III	Raytheon	End-of-Line delimiter incorrectly depicted
FTC-33	Gerry DiMassa	2/28/2001	Open	Type III	Raytheon	End-of-Line delimiter incorrectly depicted
FTC-34	John Kelley	2/28/2001	Closed	Type III	AT REQ	Iconify/Minimize Terminology
FTC-35	John Kelley	2/28/2001	Closed	Type III	AT REQ	ITWS/TDWR Mode Difference
FTC-44	Gerry DiMassa	3/8/2001	Closed	Type III	Raytheon	CISCO Router Protocol
FTC-54	Tom Weiss	3/20/2001	Closed	Type III	AF REQ	Maintenance Requirements and 2 person lift
FTC-56	Steve Viveiros	3/27/2001	Closed STR7436	Type III	Raytheon	Missing reference documents
FTC-94	Steve Viveiros	4/4/2001	Closed STR7445	Type III	Raytheon	Maintenance for UconX
FTC-95	Steve Viveiros	4/4/2001	Closed STR7446	Type III	Raytheon	Maintenance for DLT 4000 Digital Linear Tape Recorder
FTC-102	Donne Wedge	4/18/2001	Closed STR7452	Type III	Raytheon	Site Adaptation Document (CDRL A15005-001)
FTC-105	Gerry DiMassa	4/25/2001	Open	Type III	AT REQ	28 ORD Requirements are Deemed Untestable (By ACT-320)
FTC-106	Gerry DiMassa	4/25/2001	Open	Type III	ATB-260	Bit Error Rate
FTC-153	Steve Viveiros	5/11/2001	Closed	Type III	ATB-260	To Print the Blanking Alarm Period
FTC-157	Steve Viveiros	5/11/2001	Closed	Type III	ATB-260	To Print the Watchdog Timer Interval Period
FTC-170	Steve Viveiros	5/24/2001	Open	Type III	ATB-260	Archive Tape Transfer time selection
FTC-184	Gerry DiMassa	5/30/2001	Open	Type III	ATB-260	Transfer Time Constraint
Build:	1019/1032					
FTC-6	Jim Olivo	2/20/2001	Closed	Type III	ATB-260/AOS-250	Interface Status
FTC-9	Tom Weiss	2/26/2001	Open	Type III	AT REQ	Product Status Box Color Inconsistency
FTC-11	Gerry DiMassa	2/27/2001	Closed	TYPE II	ATB-260/AOS-250	ASR-9 Cable Installation
FTC-12	Gerry DiMassa	2/27/2001	Closed STR7396	Type III	Raytheon	ADAS Adaptation Problem
FTC-14	Gerry DiMassa	2/27/2001	Closed	Type III	ATB-260	NEXRAD Free Text Message
FTC-15	Gerry DiMassa	2/27/2001	Open	Type III	AT REQ	NEXRAD Test Pattern
FTC-16	Gerry DiMassa	2/27/2001	Open	Type III	ATB-260	ISO OSI reference model (TDWR Backup Interface)
FTC-17	Gerry DiMassa	2/27/2001	Closed STR7397	Type III	ATB-260	DFU time sync message
FTC-20	Gerald Mikuenski	2/27/2001	Closed	Type III	ATB-260/AOS-250	Observation - MDT Colors/Background

Discrepancy#	Originator	Date Written	Status	Priority	Assigned	Title
FTC-25	Jimmy "C"	2/27/2001	Closed	Type III	AT REQ	Observation - Fonts/Colors
Build:	1026/1041					
FTC-185	Steve Viveiros	5/30/2001	Closed	Type III	AT REQ	View and Install Runway Configurations
FTC-186	Gerry DiMassa	6/10/2002	Open STR-7397	Type III	ATB-260	TDWR Interface Documentation Issues
Build:	1034/1048					
IAH-1	Betty Bayse	10/4/2001	Closed	Type III	AT REQ	Audible Alarm on Ribbon Displays
IAH-2	Mike Geiger	10/4/2001	Closed	Type III	AT REQ	Precipitation Display
IAH-3	Pat Hart	10/4/2001	Closed	Type III	AT REQ	Temperature
IAH-4	Pat Hart	10/4/2001	Closed	Type III	AT REQ	TWINDS Display Box
IAH-5	Pat Hart	10/4/2001	Open	Type III	AT REQ	ASR Button
IAH-6	Pat Hart	10/4/2001	Open	Type III	AT REQ	ICONIFY
IAH-7	Pat Hart	10/4/2001	Closed	Type III	AT REQ	Sensor Status
IAH-8	Pat Hart	10/4/2001	Open	Type III	AT REQ	Clock
IAH-9	Rod Edgin	10/4/2001	Open	Type III	ATB-260/AOS-250	Sensor Status
IAH-10	Tom Weiss	10/4/2001	Closed STR7615	Type III	Raytheon	Overlay Redundancy
IAH-11	Rod Edgin	10/5/2001	Closed	Type III	ATB-260/AOS-250	Audible Alarm on MDT
IAH-12	Donne Wedge	10/5/2001	Closed	Type III	ATB-260	Changing Adaptation Parameters
IAH-13	Pat Hart	10/5/2001	Closed	Type III	AT REQ	Product Status Bars to Correspond to Alert Status Boxes
IAH-14	Pat Hart	10/5/2001	Closed	Type III	AT REQ	Draw a Box Around Area to Zoom
IAH-15	Donne Wedge	10/8/2001	Closed	Type III	ATB-260	ITWS Software Load Process
IAH-16	Donne Wedge	10/16/2001	Closed	Type III	Raytheon	Archive Retrieval
IAH-17	Gerry DiMassa	10/16/2001	Closed STR7614	Type III	Raytheon	Change in ADNS address
IAH-18	Gerry DiMassa	10/18/2001	Closed	Type III	Raytheon	Excessive ADAS Alarms
IAH-19	Rod Edgin	10/19/2001	Closed	Type III	ATB-260/AOS-250	Configuration data difficult to find
IAH-20	Rod Edgin	10/19/2001	Closed	Type III	AT REQ	SD overlay window
IAH-22	Steve Viveiros	10/19/2001	Closed	TYPE I	Raytheon	SD CPU Utilization Alerts and Alarms

Discrepancy#	Originator	Date Written	Status	Priority	Assigned	Title
IAH-23	Rob Glover	11/11/2001	Closed	Type III		Weather Display
Build:	1038/1059					
IAH-24	Dennis Warfield	11/25/2001	Closed	Type III		AP
IAH-244	Rod Edgin	11/28/2001	Closed	Type III	Raytheon	Adaptation data change
IAH-26	Steve Viveiros	11/28/2001	Closed	Type III	ATB-260/AOS-250	MPS Status/Control Button
IAH-27	Betty Bayse	2/4/2002	Closed	TYPE I	AT REQ	ITWS vs TDWR Ribbon Display
IAH-28	Betty Bayse	3/7/2002	Closed	Type III	Documentation	No data on NEXRAD and/or ASR-9
IAH-29	Betty Bayse	3/27/2002	Closed STR8030	TYPE I	Raytheon	Re-opening of Runway 15R/33L on May 24, 2002______________
Build:	1028/1045					
MCI-60	Amy Birlingmair	9/17/2001	Open	TYPE II	AOS-250	TDWR Weather Scenario Test Tape
MCI-61	Amy Birlingmair	9/20/2001	Closed	Type III	AOS-250	System Administrator
MCI-39	Amy Birlingmair	8/21/2001	Open	Type III	ATB-260/AOS-250	Include keyboard control of soft keyboard
MCI-36	Bart Khatiwala	8/22/2001	Open	Type III	ATB-260	ASIS Interface
MCI-37	Bart Khatiwala	8/22/2001	Closed	Type III	AOS-250	Maintenance Procedures
MCI-38	Bart Khatiwala	8/22/2001	Open	Type III	AOS-250	No Remote Maintenance Troubleshooting
MCI-6	Carey Rolefson	8/15/2001	Closed	TYPE I	ATB-260	Tower Screen Visibility
MCI-50	Carey Rolofson	8/31/2001	Open	Type III	AT REQ	TDWR Backup Mode
MCI-23	Carey Rolofson	8/16/2001	Open	Type III	AT REQ	TWINDS Display
MCI-24	Carey Rolofson	8/16/2001	Closed	Type III	AT REQ	NEXRAD TOPS Capability
MCI-25	Carey Rolofson	8/16/2001	Closed STR7594	Type III	Raytheon	MCI Sensor
MCI-44	Carey Rolofson	8/21/2001	Closed	Type III	ATB-260	NEXRAD Source
MCI-45	Carey Rolofson	8/21/2001	Closed	Type III	ATB-260	NEXRAD AP
MCI-4	Carey Rolofson	8/16/2001	Closed	TYPE I	AT REQ	Display of Weather Products from Different Sensors
MCI-8	Carey Rolofson	8/15/2001	Closed STR7609	Type III	Raytheon	Overlays
MCI-1	Donne Wedge	6/27/2001	Closed	Type III	ATB-260	Configuration of ITWS NADIN to PG Connections
MCI-3	Donne Wedge	7/16/2001	Open	Type III	ATB-260	Disconnect between IRD & ICD

Discrepancy#	Originator	Date Written	Status	Priority	Assigned	Title
MCI-56	Gerry DiMassa	9/13/2001	Closed	Type III		ASR-9/ITWS IRD ICD and ASIS Phase II Kit are Non-Compliant w/Gov't Standard
MCI-57	Gerry DiMassa	9/13/2001	Closed STR7618	Type III	Raytheon	ASR-9/ITWS ICD Incorrect
MCI-58	Gerry DiMassa	9/13/2001	Closed STR7619	Type III	Raytheon	MCI Adaptation Baseline Parameters (3 Problems)
MCI-59	Gerry DiMassa	9/13/2001	Closed	Type III	AT REQ	Additional Color Indicator for the Terminal Text Product Status Button
MCI-2	Gerry DiMassa	7/14/2001	Open	Type III	AOS-250	ADAS/ITWS T-SEL Addressing Information
MCI-21	Gerry DiMassa	8/16/2001	Closed STR7580	Type III	Raytheon	NFU Password
MCI-49	Julie Horner	8/31/2001	Closed STR7620	Type III	ACT-320	TDWR Backup Mode
MCI-51	Julie Horner	8/31/2001	Closed STR7602	TYPE I	Raytheon	Windshear ICONs
MCI-62	Julie Horner	10/18/2001	Closed	TYPE I	AT REQS	NEXRAD Tornado Vortex Signature Algorithm
MCI-12	Julie Horner	8/15/2001	Closed	Type III	ATB-260	ASIS -Box Adapter
MCI-13	Julie Horner	8/15/2001	Closed STR7593	Type III	Raytheon	NFU Data Link
MCI-14	Julie Horner	8/15/2001	Open	Type III	AF REQ	TDWR Fragment Errors and Sequence Number Errors
MCI-15	Julie Horner	8/15/2001	Closed	Type III	ACT-320	Supply an SD at the PG
MCI-16	Julie Horner	8/15/2001	Closed	Type III	ATB-260	ITWS Interface to IDS-4
MCI-17	Julie Horner	8/15/2001	Closed	Type III	ATB-260	TDWR Base Data Microwave Link
MCI-18	Julie Horner	8/15/2001	Closed	Type III	ATB-260	Networking Laser Printer
MCI-22	Julie Horner	8/16/2001	Open	Type III	ATB-260	SEM Log
MCI-40	Julie Horner	8/22/2001	Open	Type III	ATB-260	Slow and cumbersome Playback Mode
MCI-41	Julie Horner	8/22/2001	Closed	Type III		IP Network address list and "Ping" command
MCI-42	Julie Horner	8/21/2001	Closed	Type III	AT REQ	NO LLWAS backup to TDWR
MCI-43	Julie Horner	8/21/2001	Closed	TYPE I	AT REQ	No TWIP data on TDWR Backup function
MCI-47	Julie Horner	8/29/2001	Closed STR7601	Type III	Raytheon	Equipment modifications
MCI-48	Julie Horner	8/29/2001	Closed	Type III	ATB-260	Patch Panel
MCI-5	Julie Horner	8/16/2001	Closed	TYPE II	ATB-260	Critical Power
MCI-7	Julie Horner	8/15/2001	Closed STR7586	TYPE I	Raytheon	TRACON SD Screen
MCI-9	Julie Horner	8/15/2001	Closed	Type III	ATB-260	Magnetic North vs True North
MCI-46	Paul Hansen	8/18/2001	Closed	Type III	ATB-260	False wx echos on 100/200 ranges

Discrepancy#	Originator	Date Written	Status	Priority	Assigned	Title
MCI-52	Steve Viveiros	8/17/2001	Closed STR7863	Type III	Raytheon	Watchdog Timer (TTR-008)
MCI-53	Steve Viveiros	8/17/2001	Closed STR7604	Type III	Raytheon	Message Function Code (TTR-001)
MCI-54	Steve Viveiros	8/17/2001	Closed STR7605	Type III	Raytheon	Lower Alarm Values (TTR-009)
MCI-55	Steve Viveiros	8/17/2001	Closed STR7606	Type III	Raytheon	State Change Message (TTR-010)
MCI-26	Steve Viveiros	8/17/2001	Open STR7595	Type III	Raytheon	Configured SD Status (TTR-002)
MCI-27	Steve Viveiros	8/17/2001	Open STR7595	Type III	Raytheon	Non-Configured SD Status (TTR-002)
MCI-28	Steve Viveiros	8/17/2001	Open STR7596	Type III	Raytheon	Disabled SD Reporting (TTR-003)
MCI-29	Steve Viveiros	8/17/2001	Closed STR7597	Type III	Raytheon	NFU/PG Configuration
MCI-30	Steve Viveiros	8/17/2001	Closed STR7598	Type III	Raytheon	Imminent Shutdown Alarm Message
MCI-31	Steve Viveiros	8/17/2001	Open	Type III	ATB-260/AOS-250	PG Mode Command Message
MCI-32	Steve Viveiros	8/17/2001	Closed STR7599	Type III	Raytheon	TDWR #1 Link State Command (TTR-006)
MCI-33	Steve Viveiros	8/17/2001	Closed STR7621	Type III	Raytheon	Alphanumeric and Blanking Alarms (TTR-007)
Build:	1030/1050					
MCI-34	Laurie Ratliff	8/17/2001	Closed	Type III	Raytheon	No documentation on site
MCI-35	Laurie Ratliff	8/17/2001	Open	Type III	AOS-250	ITWS System diagram incomplete
Build:	1030/1052					
MCI-10	Steve Viveiros	8/10/2001	Closed	Type III	AT REQ	Color Codes for TDWR Status
MCI-11	Steve Viveiros	8/10/2001	Closed	Type III	AT REQ	Using the Product Display Operational Mode Dialog Box

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APPENDIX B

AIR TRAFFIC QUESTIONNAIRE

INTEGRATED TERMINAL WEATHER SYSTEM (ITWS) OPERATIONAL TEST & EVALUATION

QUESTIONNAIRE

Prepared by:

Communication/Navigation/Surveillance
Engineering and Test Division, Weather Branch, ACT-320
William J. Hughes Technical Center
Federal Aviation Administration
Atlantic City International Airport
Atlantic City, NJ 08405

Position: TMC

Integrated Terminal Weather System (ITWS)
OT&E Questionnaire

The purpose of this questionnaire is to obtain feedback from Air Traffic Supervisors, Area Managers, Traffic Management Coordinators (TMC), Controllers-in-Charge (CIC), and other air traffic users regarding the ITWS products and the Situation Display (SD).

Feedback from the users is a very important component of the Federal Aviation Administration's (FAA) evaluation of the ITWS. Your responses to this questionnaire will provide important information to FAA ITWS program managers regarding the operational suitability of ITWS. Therefore, please respond to all questions as honestly and thoroughly as possible.

Responses to this questionnaire will remain ANONYMOUS and CONFIDENTIAL. A report will be written on the results of this questionnaire, summarizing respondents' comments; however no one will be identified or associated with any specific comment.

Feel free to add additional comments or questions anywhere within this questionnaire.

Please use the five point scale below to rate the ITWS products on the Situation Display (SD) and the Ribbon Display Terminal (RBDT). This scale will be used to rate the operational utility, acceptance, and readability of the ITWS products. The rating scale is defined below and should be used when assessing each one of the products.

Rating	Descriptor	Definition
1	***Consistently Enhances***	Consistently enhances your ability to do your job tasks; **leads** to enhanced job performance.
2	**Frequently Enhances**	Frequently enhances your ability to perform your job task when utilizing the product; **may lead** to enhanced job performance;
3	**Neutral**	Enables you to do your job tasks when utilizing the product; **does not lead** to degradation nor enhancement of job performance;
4	**Frequently Hinders**	Frequently hinders you to do your job task when utilizing the product; **may lead** to degradation of job performance;
5	**Consistently Hinders**	Consistently hinders your ability to do your job tasks; **leads** to degradation of job performance.
NA	**Not Applicable**	You have never used the product in question.

Instructions: Please circle the appropriate response and provide comments where appropriate.

UTILITY of WEATHER PRODUCTS and FUNCTIONALITY

PRODUCT/FUNCTIONALITY	Consistently Enhances	Frequently Enhances	Neutral	Frequently Hinders	Consistently Hinders	N/A
1. ITWS Precipitation with AP Removed	1	2	3	4	5	NA
2. ITWS Precipitation with AP Flagged	1	2	3	4	5	NA
3. Long Range Precipitation	1	2	3	4	5	NA
4. Storm Motion	1	2	3	4	5	NA
5. Storm Cell Information	1	2	3	4	5	NA
6. Storm Extrapolated Position	1	2	3	4	5	NA
7. Lightning Product	1	2	3	4	5	NA
8. Microburst/Windshear Detection	1	2	3	4	5	NA
9. Terminal Winds	1	2	3	4	5	NA
10. Gust Fronts	1	2	3	4	5	NA
11. ATIS Countdown Timer	1	2	3	4	5	NA
12. Tornado	1	2	3	4	5	NA
13. Ribbon Display Terminal	1	2	3	4	5	NA
14. Pan	1	2	3	4	5	NA
15. Zoom	1	2	3	4	5	NA

Please provide any comments or suggestions you may have regarding the products or functions listed above. For products/functions assigned a rating of 4 or 5, what changes would make the product/function more useful?

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EASE OF USE AND READABILITY OF WEATHER PRODUCTS AND FUNCTIONALITY

Using the rating scale described below, please rate the ease of use and readability of each of the ITWS products and functions listed below by circling the appropriate number.

Rating	Descriptor	Definition
1	*Completely Acceptable*	Product/Function is completely acceptable for performing your job tasks. No changes are necessary.
2	**Reasonably Acceptable**	Product/Function is reasonably acceptable for performing your job tasks. No changes are necessary.
3	**Borderline**	Product/Function is usable for performing your job tasks; however, minor changes would improve product/function.
4	**Moderately Unacceptable**	Product/Function is barely usable for performing your job tasks and considerable changes are necessary.
5	**Completely Unacceptable**	Product/Function is not usable for performing your job tasks. Product/function needs to be redesigned.
NA	**Not Applicable**	You have never used the product in question.

PRODUCTS/FUNCTIONS	Completely Acceptable	Reasonably Acceptable	Borderline	Moderately Unacceptable	Completely Unacceptable	N/A
16. ITWS Precipitation with AP Removed						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA
17. ITWS Precipitation with AP Flagged						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA
18. Long Range Precipitation						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA
19. Storm Motion						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA

PRODUCTS/FUNCTIONS	Completely Acceptable	Reasonably Acceptable	Borderline	Moderately Unacceptable	Completely Unacceptable	N/A
20. Storm Cell Information						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA
21. Storm Extrapolated Position						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA
22. Lightning Product						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA
23. Microburst/Windshear Detection						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA
24. Terminal Winds						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA
25. Gust Fronts						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA
26. ATIS Countdown Timer						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA
27. Tornado						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA
28. Ribbon Display Terminal						
a. Ease of Use	1	2	3	4	5	NA
b. Readability (color, font size, symbology)	1	2	3	4	5	NA
29. Pan						
a. Ease of Use	1	2	3	4	5	NA

PRODUCTS/FUNCTIONS	**Completely Acceptable**	**Reasonably Acceptable**	**Borderline**	**Moderately Unacceptable**	**Completely Unacceptable**	**N/A**
30. Zoom						
a. Ease of Use	1	2	3	4	5	NA
31. Multiple Weather Windows						
a. Ease of Use	1	2	3	4	5	NA

If any of the products or functions listed on previous page where assigned a rating of 4 or 5, please describe the problem. Please provide comments or suggestions that would improve the product/function.

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GENERAL DISPLAY QUESTIONS:

32. In a control tower environment do daylight conditions affect the readability of the display? If yes, please explain.

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33. In a control tower environment do nighttime conditions affect the readability of the display? If yes, please explain.

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34. Were there any colors that you had difficulty differentiating between? If yes, what color changes do you suggest?

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Please provide any other comments or suggestions you may have regarding the products, display, and/or ITWS system in general.

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METEOROLOGICAL INTERPRETATION

Using the rating scale described below, please rate the ease of use and readability of each of the ITWS products and functions listed below by circling the appropriate number.

Rating	Descriptor	Definition
1	***Completely Acceptable***	Product is completely acceptable for performing your job tasks. No changes are necessary.
2	**Reasonably Acceptable**	Product is reasonably acceptable for performing your job tasks. No changes are necessary.
3	**Borderline**	Product is usable for performing your job tasks; however, minor changes would improve product.
4	**Moderately Unacceptable**	Product is barely usable for performing your job tasks and considerable changes are necessary.
5	**Completely Unacceptable**	Product is not usable for performing your job tasks. Product needs to be redesigned.
NA	**Not Applicable**	You have never used the product in question.

PRODUCT	**Completely Acceptable**	**Reasonably Acceptable**	**Borderline**	**Moderately Unacceptable**	**Completely Unacceptable**	**N/A**
35. ITWS Precipitation with AP Removed	1	2	3	4	5	NA
36. ITWS Precipitation with AP Flagged	1	2	3	4	5	NA
37. Long Range Precipitation	1	2	3	4	5	NA
38. Storm Motion	1	2	3	4	5	NA
39. Storm Cell Information	1	2	3	4	5	NA

PRODUCT	**Completely Acceptable**	**Reasonably Acceptable**	**Borderline**	**Moderately Unacceptable**	**Completely Unacceptable**	**N/A**
40. Storm Extrapolated Position	1	2	3	4	5	NA
41. Lightning Product	1	2	3	4	5	NA
42. Microburst/Windshear Detection	1	2	3	4	5	NA
43. Terminal Winds	1	2	3	4	5	NA
44. Gust Fronts	1	2	3	4	5	NA
45. Tornado	1	2	3	4	5	NA

46. Did you require any assistance in interpreting the meteorological information on the SD?

YES NO

If YES, please explain.

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THANK YOU FOR YOUR TIME, CONSIDERATION, AND COOPERATION!!

APPENDIX C

AIR TRAFFIC WORKLOAD STUDY

Integrated Terminal Weather System (ITWS) Operational Test & Evaluation

Workload Analysis for Tower/TRACON

Modified Cooper Harper (MCH) Workload Scale

Operator mental workload is one component used to assess the suitability of an operational system. In order to assess mental workload while performing specific tasks during convective weather, the Modified Cooper Harper (MCH) workload scale is being administered to measure overall operator mental workload.

INSTRUCTIONS

- Please read each question and read the difficulty and operator demand descriptions.
- Then indicate your mental workload for each of the tasks by circling the number (1-10) on the right hand side of the scale.
- Choose the rating number that most closely matches your perception of mental workload in performing these tasks during convective weather. These ratings **should** assume the use of ITWS.
- Each task is listed on a separate page accompanied by the workload rating scale.
- Please read the descriptions regarding difficulty level and operator demand level carefully before circling your rating score.
- Remember to rate your workload for each task during convective weather only using ITWS and your current weather platforms.

Tower/TRACON Tasks:

1. Planning air traffic flow
2. Planning airspace use
3. Decisions on rerouting aircraft
4. Avoidance of adverse weather
5. Choosing runways
6. Changing runways

1. Rate your mental workload for **planning air traffic flow** during convective weather.

	Difficulty Level	Description of Operator Demand	Rating
Low	Very Easy, Highly Desirable	Operator mental effort is minimal and desired performance is easily attainable.	1
	Easy, Desirable	Operator mental effort is low and desired performance is attainable.	2
	Fair, Mild Difficulty	Acceptable operator mental effort is required to attain adequate system performance.	3
Medium	Minor but Annoying Difficulty	Moderately high operator mental effort is required to attain adequate system performance.	4
	Moderately Objectionable Difficulty	High operator mental effort is required to attain adequate system performance	5
	Very Objectionable but Tolerable Difficulty	Maximum operator mental effort is required to attain adequate system performance.	6
High	Major Difficulty	Maximum operator mental effort is required to bring errors to moderate level.	7
	Major Difficulty	Maximum operator mental effort is required to avoid large or numerous errors.	8
	Major Difficulty	Intense operator mental effort is required to accomplish task, but frequent or numerous errors persist.	9
	Impossible	Instructed task cannot be accomplished reliably.	10

2. Rate your mental workload for **planning airspace use** during convective weather.

	Difficulty Level	Description of Operator Demand	Rating
Low	Very Easy, Highly Desirable	Operator mental effort is minimal and desired performance is easily attainable.	1
	Easy, Desirable	Operator mental effort is low and desired performance is attainable.	2
	Fair, Mild Difficulty	Acceptable operator mental effort is required to attain adequate system performance.	3
Medium	Minor but Annoying Difficulty	Moderately high operator mental effort is required to attain adequate system performance.	4
	Moderately Objectionable Difficulty	High operator mental effort is required to attain adequate system performance	5
	Very Objectionable but Tolerable Difficulty	Maximum operator mental effort is required to attain adequate system performance.	6
High	Major Difficulty	Maximum operator mental effort is required to bring errors to moderate level.	7
	Major Difficulty	Maximum operator mental effort is required to avoid large or numerous errors.	8
	Major Difficulty	Intense operator mental effort is required to accomplish task, but frequent or numerous errors persist.	9
	Impossible	Instructed task cannot be accomplished reliably.	10

3. Rate your mental workload for **decisions on rerouting aircraft** during convective weather.

	Difficulty Level	Description of Operator Demand	Rating
Low	Very Easy, Highly Desirable	Operator mental effort is minimal and desired performance is easily attainable.	1
Low	Easy, Desirable	Operator mental effort is low and desired performance is attainable.	2
Low	Fair, Mild Difficulty	Acceptable operator mental effort is required to attain adequate system performance.	3
Medium	Minor but Annoying Difficulty	Moderately high operator mental effort is required to attain adequate system performance.	4
Medium	Moderately Objectionable Difficulty	High operator mental effort is required to attain adequate system performance	5
Medium	Very Objectionable but Tolerable Difficulty	Maximum operator mental effort is required to attain adequate system performance.	6
High	Major Difficulty	Maximum operator mental effort is required to bring errors to moderate level.	7
High	Major Difficulty	Maximum operator mental effort is required to avoid large or numerous errors.	8
High	Major Difficulty	Intense operator mental effort is required to accomplish task, but frequent or numerous errors persist.	9
	Impossible	Instructed task cannot be accomplished reliably.	10

4. Rate your mental workload for **avoidance of adverse weather** during convective weather.

	Difficulty Level	Description of Operator Demand	Rating
Low	Very Easy, Highly Desirable	Operator mental effort is minimal and desired performance is easily attainable.	1
	Easy, Desirable	Operator mental effort is low and desired performance is attainable.	2
	Fair, Mild Difficulty	Acceptable operator mental effort is required to attain adequate system performance.	3
Medium	Minor but Annoying Difficulty	Moderately high operator mental effort is required to attain adequate system performance.	4
	Moderately Objectionable Difficulty	High operator mental effort is required to attain adequate system performance	5
	Very Objectionable but Tolerable Difficulty	Maximum operator mental effort is required to attain adequate system performance.	6
High	Major Difficulty	Maximum operator mental effort is required to bring errors to moderate level.	7
	Major Difficulty	Maximum operator mental effort is required to avoid large or numerous errors.	8
	Major Difficulty	Intense operator mental effort is required to accomplish task, but frequent or numerous errors persist.	9
	Impossible	Instructed task cannot be accomplished reliably.	10

5. Rate your mental workload for **choosing runways** during convective weather.

	Difficulty Level	Description of Operator Demand	Rating
Low	Very Easy, Highly Desirable	Operator mental effort is minimal and desired performance is easily attainable.	1
	Easy, Desirable	Operator mental effort is low and desired performance is attainable.	2
	Fair, Mild Difficulty	Acceptable operator mental effort is required to attain adequate system performance.	3
Medium	Minor but Annoying Difficulty	Moderately high operator mental effort is required to attain adequate system performance.	4
	Moderately Objectionable Difficulty	High operator mental effort is required to attain adequate system performance	5
	Very Objectionable but Tolerable Difficulty	Maximum operator mental effort is required to attain adequate system performance.	6
High	Major Difficulty	Maximum operator mental effort is required to bring errors to moderate level.	7
	Major Difficulty	Maximum operator mental effort is required to avoid large or numerous errors.	8
	Major Difficulty	Intense operator mental effort is required to accomplish task, but frequent or numerous errors persist.	9
	Impossible	Instructed task cannot be accomplished reliably.	10

6. Rate your mental workload for **changing runways** during convective weather.

	Difficulty Level	Description of Operator Demand	Rating
Low	Very Easy, Highly Desirable	Operator mental effort is minimal and desired performance is easily attainable.	1
	Easy, Desirable	Operator mental effort is low and desired performance is attainable.	2
	Fair, Mild Difficulty	Acceptable operator mental effort is required to attain adequate system performance.	3
Medium	Minor but Annoying Difficulty	Moderately high operator mental effort is required to attain adequate system performance.	4
	Moderately Objectionable Difficulty	High operator mental effort is required to attain adequate system performance	5
	Very Objectionable but Tolerable Difficulty	Maximum operator mental effort is required to attain adequate system performance.	6
High	Major Difficulty	Maximum operator mental effort is required to bring errors to moderate level.	7
	Major Difficulty	Maximum operator mental effort is required to avoid large or numerous errors.	8
	Major Difficulty	Intense operator mental effort is required to accomplish task, but frequent or numerous errors persist.	9
	Impossible	Instructed task cannot be accomplished reliably.	10

Integrated Terminal Weather System (ITWS)
Operational Test & Evaluation

Workload Analysis
for
ARTCC

Modified Cooper Harper (MCH) Workload Scale

Operator mental workload is one component used to assess the suitability of an operational system. In order to assess mental workload while performing specific tasks during convective weather, the Modified Cooper Harper (MCH) workload scale is being administered to measure overall operator mental workload.

INSTRUCTIONS

Please read each question and read the difficulty and operator demand descriptions.
Then indicate your mental workload for each of the tasks by circling the number (1-10) on the right hand side of the scale.
Choose the rating number that most closely matches your perception of mental workload in performing these tasks during convective weather. These ratings should assume the use of ITWS.
Each task is listed on a separate page accompanied by the workload rating scale.
Please read the descriptions regarding difficulty level and operator demand level carefully before circling your rating score.
Remember to rate your workload for each task during convective weather only using ITWS and your current weather platforms.

ARTCC Tasks:

1. Planning air traffic flow
2. Planning airspace use
3. Decisions on rerouting aircraft
4. Avoidance of adverse weather

1. Rate your mental workload for planning air traffic flow during convective weather.

	Difficulty Level	Description of Operator Demand	Rating
Low	Very Easy, Highly Desirable	Operator mental effort is minimal and desired performance is easily attainable.	1
	Easy, Desirable	Operator mental effort is low and desired performance is attainable.	2
	Fair, Mild Difficulty	Acceptable operator mental effort is required to attain adequate system performance.	3
Medium	Minor but Annoying Difficulty	Moderately high operator mental effort is required to attain adequate system performance.	4
	Moderately Objectionable Difficulty	High operator mental effort is required to attain adequate system performance	5
	Very Objectionable but Tolerable Difficulty	Maximum operator mental effort is required to attain adequate system performance.	6
High	Major Difficulty	Maximum operator mental effort is required to bring errors to moderate level.	7
	Major Difficulty	Maximum operator mental effort is required to avoid large or numerous errors.	8
	Major Difficulty	Intense operator mental effort is required to accomplish task, but frequent or numerous errors persist.	9
	Impossible	Instructed task cannot be accomplished reliably.	10

2. Rate your mental workload for planning airspace use during convective weather.

	Difficulty Level	Description of Operator Demand	Rating
Low	Very Easy, Highly Desirable	Operator mental effort is minimal and desired performance is easily attainable.	1
	Easy, Desirable	Operator mental effort is low and desired performance is attainable.	2
	Fair, Mild Difficulty	Acceptable operator mental effort is required to attain adequate system performance.	3
Medium	Minor but Annoying Difficulty	Moderately high operator mental effort is required to attain adequate system performance.	4
	Moderately Objectionable Difficulty	High operator mental effort is required to attain adequate system performance	5
	Very Objectionable but Tolerable Difficulty	Maximum operator mental effort is required to attain adequate system performance.	6
High	Major Difficulty	Maximum operator mental effort is required to bring errors to moderate level.	7
	Major Difficulty	Maximum operator mental effort is required to avoid large or numerous errors.	8
	Major Difficulty	Intense operator mental effort is required to accomplish task, but frequent or numerous errors persist.	9
	Impossible	Instructed task cannot be accomplished reliably.	10

3. Rate your mental workload for decisions on rerouting aircraft during convective weather.

	Difficulty Level	Description of Operator Demand	Rating
Low	Very Easy, Highly Desirable	Operator mental effort is minimal and desired performance is easily attainable.	1
	Easy, Desirable	Operator mental effort is low and desired performance is attainable.	2
	Fair, Mild Difficulty	Acceptable operator mental effort is required to attain adequate system performance.	3
Medium	Minor but Annoying Difficulty	Moderately high operator mental effort is required to attain adequate system performance.	4
	Moderately Objectionable Difficulty	High operator mental effort is required to attain adequate system performance	5
	Very Objectionable but Tolerable Difficulty	Maximum operator mental effort is required to attain adequate system performance.	6
High	Major Difficulty	Maximum operator mental effort is required to bring errors to moderate level.	7
	Major Difficulty	Maximum operator mental effort is required to avoid large or numerous errors.	8
	Major Difficulty	Intense operator mental effort is required to accomplish task, but frequent or numerous errors persist.	9
	Impossible	Instructed task cannot be accomplished reliably.	10

4. Rate your mental workload for avoidance of adverse weather during convective weather.

	Difficulty Level	Description of Operator Demand	Rating
Low	Very Easy, Highly Desirable	Operator mental effort is minimal and desired performance is easily attainable.	1
	Easy, Desirable	Operator mental effort is low and desired performance is attainable.	2
	Fair, Mild Difficulty	Acceptable operator mental effort is required to attain adequate system performance.	3
Medium	Minor but Annoying Difficulty	Moderately high operator mental effort is required to attain adequate system performance.	4
	Moderately Objectionable Difficulty	High operator mental effort is required to attain adequate system performance	5
	Very Objectionable but Tolerable Difficulty	Maximum operator mental effort is required to attain adequate system performance.	6
High	Major Difficulty	Maximum operator mental effort is required to bring errors to moderate level.	7
	Major Difficulty	Maximum operator mental effort is required to avoid large or numerous errors.	8
	Major Difficulty	Intense operator mental effort is required to accomplish task, but frequent or numerous errors persist.	9
	Impossible	Instructed task cannot be accomplished reliably.	10

APPENDIX D

QUESTIONNAIRE AND WORKLOAD DATA
AT Questionnaire and Workload Results

Table D-1. MCI: Median Ratings per ITWS Product and Function

Product/Function	Utility	Ease of Use	Readability
Precipitation w/ AP Removed	2	1	1
Precipitation w/ AP Flagged	2	1.5	1.5
Long Range Precipitation	1	1	1
Storm Motion	1	1	1
Storm Cell Motion	2	1	1
Storm Extrapolated Position	1.5	2	1.5
Lightning	2	2	1
Microburst/Windshear	1	1	1
Terminal Winds	1	1	1
Gust Front	1	1	1
ATIS Countdown Timer	3	2	2
Tornado	2	2	1
Ribbon Display Terminal	2	1	1
Pan	2	1	N/A
Zoom	2	1	N/A

Note: Median values are reported for utility, ease of use, and readability for each product/function.
Scale: 1 = Consistently Enhances, 2 = Frequently Enhances, 3 = Neutral, 4 = Frequently Hinders, 5 = Consistently Hinders.

The Modified Cooper Harper (MCH) mental workload scale was used to measure overall perceived user mental workload as it applied to operational use of the ITWS for specific air traffic tasks. The 10-point workload scale rating definitions ranged from:

1 - very easy, highly desirable. Operator mental effort is minimal and desired performance is easily attainable, to
10 - Impossible. Instructed task cannot be accomplished reliably.

Lower rating scores indicated lower perceived workload in performance of any of the identified tasks during a convective weather event. Conversely, higher scores indicated greater perceived workload.

Table D-2 MCI Median Meteorological Interpretation Ratings per Product

Product/Function	Meteorological Interpretation
Precipitation w/ AP Removed	1
Precipitation w/ AP Flagged	1
Long Range Precipitation	1
Storm Motion	1
Storm Cell Motion	1
Storm Extrapolated Position	2
Lightning	1
Microburst/Windshear	1
Terminal Winds	1
Gust Front	1
Tornado	2

Note: Median values are reported for meteorological interpretation for each product. Scale: 1 = Completely Acceptable, 2 = Reasonably Acceptable, 3 = Borderline, 4 = Moderately Unacceptable, 5 = Completely Unacceptable

Table D-3 Median Ratings per ITWS Product and Function for I90 Terminal Users

Product/Function	Utility	Ease of Use	Readability
Precipitation w/ AP Removed	2	2	1
Precipitation w/ AP Flagged	2	2	2
Long Range Precipitation	2	2	2
Storm Motion	1	2	1
Storm Cell Motion	1	2	1.5
Storm Extrapolated Position	2	2	2
Lightning	2	2	1.5
Microburst/Windshear	1	1	1
Terminal Winds	2	1	1
Gust Front	2	1	1
ATIS Countdown Timer	3	2	2
Tornado	1.5	1	1
Ribbon Display Terminal	2	2	1
Pan	2	1.5	N/A
Zoom	1.5	1	N/A

Note: Median values are reported for utility, ease of use, and readability for each product/function. Scale: 1 = Consistently Enhances, 2 = Frequently Enhances, 3 = Neutral, 4 = Frequently Hinders, 5 = Consistently Hinders.

Table D-4 Median Ratings per ITWS Product and Function for ZHU Users

Product/Function	Utility		Ease of Use		Readability	
	TMC	CWSU	TMC	CWSU	TMC	CWSU
Precipitation w/ AP Removed	2	2	2	1	2	1
Precipitation w/ AP Flagged	2	2	2	2	2	2
Long Range Precipitation	2	3	1.5	2	1.5	2
Storm Motion	1	1.5	1	1	1	1
Storm Cell Motion	1.5	2	1	1.5	1.5	1.5
Storm Extrapolated Position	1.5	2	2	1.5	2	1.5
Lightning	2	3	2	3	2	2
Microburst/Windshear	1.5	2	1.5	1	1.5	2
Terminal Winds	2	1	2	1	2	1
Gust Front	1	1.5	1.5	1	1.5	1
ATIS Countdown Timer	3	3	3.5	N/A	3	N/A
Tornado	2	3	1	2	1.5	2
Ribbon Display Terminal	3	1.5	2.5	1	2	1
Pan	2	3	1	2.5	N/A	N/A
Zoom	2	1.5	1	2	N/A	N/A

Note: Median values are reported for utility, ease of use, and readability for each product/function. Scale: 1 = Consistently Enhances, 2 = Frequently Enhances, 3 = Neutral, 4 = Frequently Hinders, 5 = Consistently Hinders.

Table D-5 Median Meteorological Interpretation Ratings per Product for I90 Terminal Users

Product/Function	Meteorological Interpretation
Precipitation w/ AP Removed	2
Precipitation w/ AP Flagged	2
Long Range Precipitation	1.5
Storm Motion	1
Storm Cell Motion	1
Storm Extrapolated Position	1.5
Lightning	1.5
Microburst/Windshear	1
Terminal Winds	1
Gust Front	1
Tornado	1

Note: Median values are reported for meteorological interpretation for each product. Scale: 1 = Completely Acceptable, 2 = Reasonably Acceptable, 3 = Borderline, 4 = Moderately Unacceptable, 5 = Completely Unacceptable

Table D-6 Median Meteorological Interpretation Ratings per Product for ZHU Users

Product/Function	Meteorological	Interpretation
	TMU	CWSU
Precipitation w/ AP Removed	1	1
Precipitation w/ AP Flagged	1.5	1.5
Long Range Precipitation	1.5	2
Storm Motion	1	1.5
Storm Cell Motion	1	1.5
Storm Extrapolated Position	2	1
Lightning	2	2
Microburst/Windshear	1	1
Terminal Winds	2	1
Gust Front	1	1
Tornado	1	4

Note: Median values are reported for meteorological interpretation for each product. Scale: 1 = Completely Acceptable, 2 = Reasonably Acceptable, 3 = Borderline, 4 = Moderately Unacceptable, 5 = Completely Unacceptable

Figure D-1. Pre/Post-MCH Workload Comparisons – MCI Terminal Area Tasks

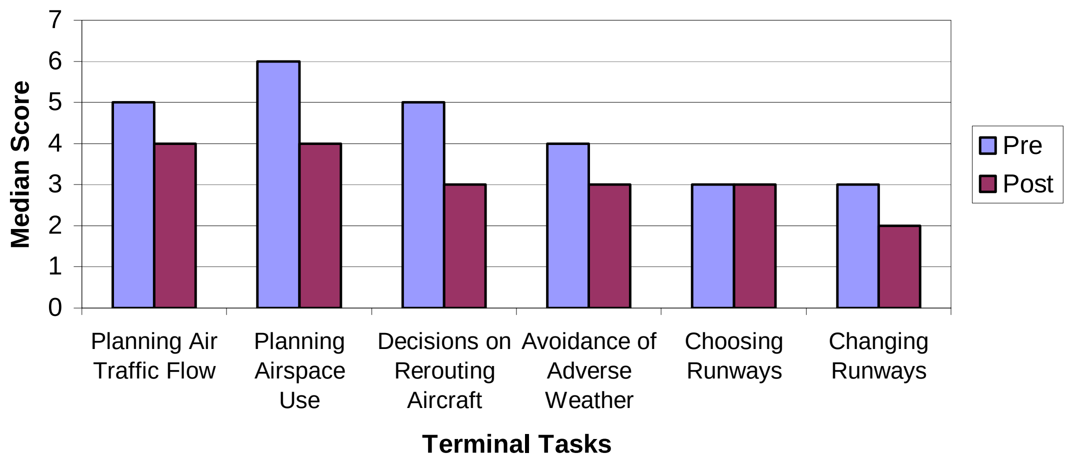

Figure D-2. Pre/Post-MCH Workload Comparisons – I90 Terminal Area Tasks

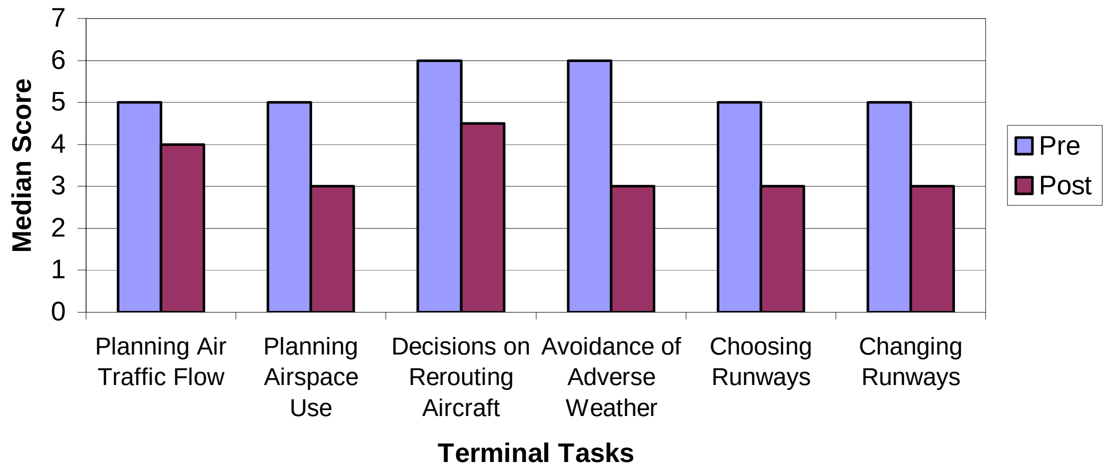

Figure D-3. Pre/Post-MCH Workload Comparisons – ZHU Area Tasks